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Reshaping Montana's Agriculture

The Forty-first Annual Report

of the

Montana Agricultural Experiment Station

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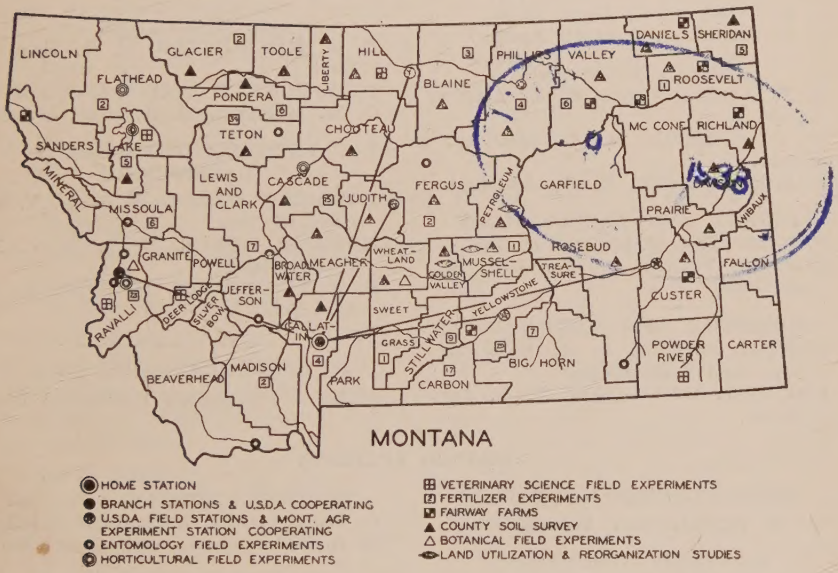
F. B. Linfield, Director



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MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

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[3]Cooperating with the United States Department of Agriculture.

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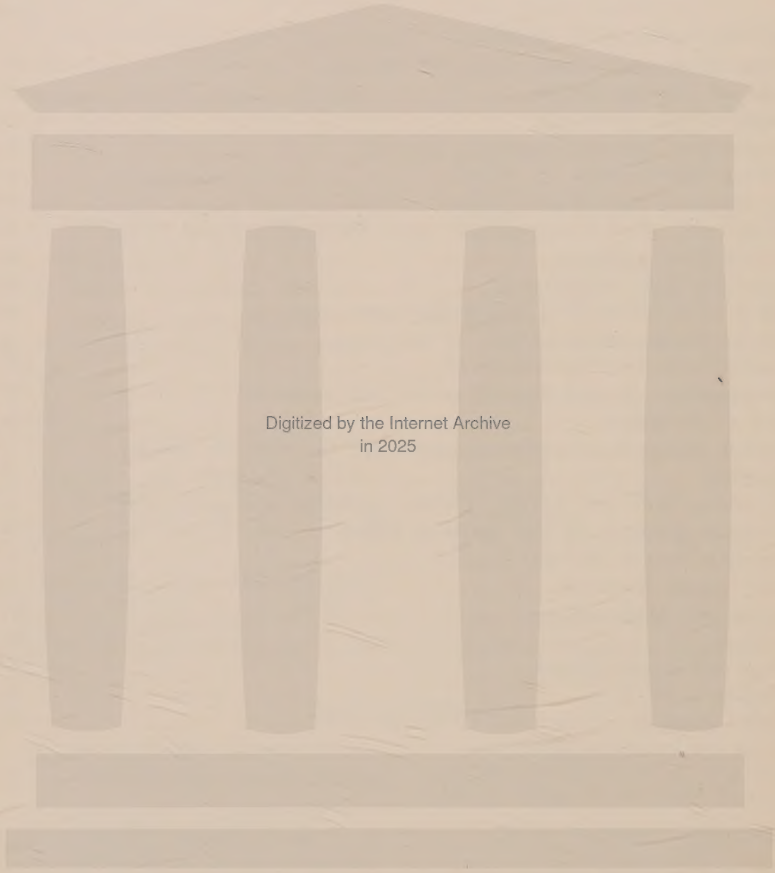

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Reshaping Montana's Agriculture

FACING NEW AGRICULTURAL PROBLEMS

Each passing year brings to us some new vision of the problems of agriculture. Soon after the close of the World War it was apparent that our agricultural production had been speeded up beyond the nation's normal need for farm produce, and consequently prices dropped to a very low level and were quite out of line with the prices of other commodities. Many and various plans were proposed to correct this condition, among them the McNary-Haugen and the Debenture proposals, the National Farm Board, and the Allotment plan. The first two of these proposals were intended to turn the surplus from the local market into the export trade and the allotment plan would adjust production to the market demand by subsidizing the farmers who reduced their crop acreage. The ultimate purpose of all these plans was to increase the price to the farmer. As the study progressed, however, it was evident that the problems involved called for more than an immediate answer. Fundamental changes in the economic and social outlook must be considered in attempting any solution.

As the general business depression has continued it has become evident that other factors have intensified the agricultural situation and complicated the problem. The increasing use of mechanical power on the farm and throughout the nation has greatly reduced the need for horses and has permitted turning over for other types of production some twenty-five to thirty million acres of land formerly used in providing horse feed. This increased the amount of crops on the market.

All through the nation's history, but especially during the past fifty to sixty years of rapid expansion westward, the surplus agricultural products of the nation found a large foreign market and this demand was intensified during the World War. Since then, however, the foreign market for many of our agricultural products has tended to disappear. This has been due to a variety of causes growing out of the past, many of which were intensified as a consequence of the war.

Again, the four years of this war changed the United States from a debtor nation to the largest creditor nation in the world, from an interest-paying nation to a large interest-collecting one. At the same time it greatly impoverished and disorganized many of the nations which had provided the largest export market for the products of our farms. This has greatly modified our business relations with all the world and especially with the nations of Europe. Yet another influence affecting our trade with the nations of the world is that they are not convinced that war is a thing of the past but rather that it is yet a potential event in the not distant future, to which they must give consideration and for which they must prepare. The World War brought new decisions as to what goods in the trade beween nations were contraband during war. It taught us that in these modern times not armies and navies alone, but all the peoples of the nations, are at war. Under modern conditions every productive activity of the nations is devoted directly or indirectly to providing materials, most of which are valuable for use in or necessary for carrying on the war. We well remember the slogan, "Food will win the war," and this could apply to nearly every product of the farms, mines, and factories. All nations have fully recognized that a lack of self-sufficiency was an important factor in the defeat of the enemy. Dependence on trade with foreign countries to supply the nation's needs proved a very great weakness in war time. Nations could not depend on their own shipping or on that of any other country to supply their needs for food or goods of any kind.

With war still hanging over them every major nation in the world is now striving to make itself as independent as possible of foreign goods and foreign trade. First, they are subsidizing and enlarging their agriculture; and next, by intensifying scientific research are striving to find substitutes for former imports. We note that France now has wheat to export; that England is subsidizing her agriculture and giving trade preferences to the Dominion and the colonies; that Germany is intensifying her research program and bringing every acre possible into agricultural production to overcome her dependence on imports of food and raw materials from foreign countries. Many other nations are working in the same direction, to the end, apparently, that they may be thoroughly independent of foreign commerce in so far as that is at all possible.

Thus it would appear that as long as the present world psychology persists we can hardly expect anything other than a decreasing export market for agricultural products. Hence must we not nationally plan for the present, on the basis of adjusting our agricultural production very largely to the requirements of our own country? Reasoning from the past several years' experience on the possibilities of our agriculture, will not such a policy call for a radical readjustment of our agriculture? Can anything but assured world peace make it possible to rebuild this foreign trade and bring back the foreign market for our agriculture?

In the past a large factor in the expansion and development of the agriculture of the nation has been a rapidly increasing population. In a century and a half the people of these United States have increased from four million to over 125 million. In the thirty years from 1900 to 1930 this increase was forty-five million people; but students of population trends tell us that increases in population are slowing down and that soon it will become a stationary, if not a decreasing, population in the nation. If this condition materializes the future population will not provide a market for our present basis of overproduction in agriculture, nor can we look for any further necessity for material enlargement of the cropped area of the country, but rather continued reduction, as improved crops and improved agricultural methods are developed.

A study of our agricultural production since 1900 shows that the present farm organization and the present number of farm workers are capable of producing more agricultural goods than the country can consume. This is well illustrated by the experience during the thirty years from 1900 to 1930. In that period a practically stationary agricultural population provided for all the agricultural needs of the country, including those of a forty-five million increase in national population, and also piled up a burdensome surplus. Furthermore, this occurred during the most prosperous industrial and business period in the history of the nation. Improvements in methods of production on the farm, both scientific and mechanical, made this possible.

We are further advised that like improvements in the mechanics of industrial production indicate that considerably less help, rather than more, will be required in industry even if production materially exceeds that of 1928 or 1929. Any increased demand for agricultural

products in the industrial and business centers of the country cannot be expected unless we can find new uses for our present crops or find new crops that may be valuable in industry.

Yet another factor to consider is that with the enlargement of manufacturing plants and the combinations of industry into fewer units, there is a tendency in many types of manufacturing to adapt production to the immediate market demands. This will mean high speed production at times, with intermittent layoffs for the workers. To meet this situation there is an apparent tendency for industrial enterprises in some parts of the country to transfer their plants to the open country around the cities. Electric development will convey to these factories at low cost the power needed to make this move possible. A natural consequence will be that the factory workers will also move to the country and spread out on the land around the factory. The present depression has emphasized the desirability of this plan, and the Federal Government has lent encouragement to it. The result is the subsistence homestead for the industrial worker where he may produce much of his living, such as garden vegetables, poultry, eggs, and milk. This plan lends itself especially well to intermittent industrial production and to part-time work. For the immediate future this program may have little effect on the demand for agricultural products but if it proves a desirable procedure then it will be extended to a much larger proportion of the industrial and other city workers. Such a developmenrt of this program will ultimately mean less call for the produce of the farms.

Another factor that must be considered as we look ahead, is the need that is visioned for taking fifty to seventy-five million acres of farm land out of cultivation and putting it to some less intensive use. As a result the cropped areas of the farms must, on the average, be reduced by one-seventh to one-fifth of their present area, which means either fewer farms or a reduction in the number of farmers and farm workers. It is hoped that this adjustment in cropped area will result in higher and more stable prices for farm products, while any increase in demand from the nation could be met by more intensive production methods. However, to increase acre yields in the present period of readjustment would measurably defeat the plan for better adaptation of production to demand.

The census figures of the country show that the natural rate of increase in the nation's population has in the past been considerably

greater in the rural areas than in the centers of population. The probabilities are that this greater increase in the country will continue, though probably not at so great a rate as in the past. Studies that have been made do not indicate any greater need for help on the farms in the future than at the present time. Hence the farm will have, as in the past, a surplus of young people. Up to 1930, at least, this natural increase in population in the rural areas moved to the cities and the industrial centers, but the experience of the past ten years seems to indicate that there are now more workers in the cities than are needed. Moreover, it is probable that improvements in machinery and technique will render unnecessary any material increase in the number of industrial workers. If this proves true, then some other place must be found for the population increase of the farms. Can this be at any other place than in the rural areas? To adjust this increasing farm population to a decreasing farm crop area will present a very large problem to rural people and to the nation.

A plan of regional production to aid agricultural adjustment has been discussed seriously in certain quarters. The viewpoint is that irrespective of state lines, certain types of agricultural production should be carried on only in those natural regions where the experience of the past has shown them to be especially adapted; for instance, cotton production in those areas best adapted to this crop; dairy products in the regions adjacent to the Great Lakes; wheat in the semiarid regions of the Middle West; beef cattle and sheep produced in the West, but fattened in the corn country, where also the hog will reign supreme. This philosophy would further work out a plan to measurably protect those regions in these special fields of production, by discouraging any competition from other regions, where but a limited volume of the particular products was possible. If this is the national picture with which the West has to reckon, then there will be many far-reaching and important problems for study and solution, not alone in the field of agriculture but in economics, sociology, and other directions.

This is the background out of which the agriculture of the state and the nation must be reshaped. The magnitude of the picture has only recently been recognized and there may be yet other sections to be filled in. The Experiment Station has been studying many of these problems as they have opened up. In the following pages attention is called to definite activities of the various departments in

endeavoring to solve these problems. It is clear to us that many of these situations are new and unusual and will call for more and more emphasis on the human factors in the agricultural studies of the future. The field of agricultural research must be broadened and intensified, but we must not neglect research in the productive field, because here we have yet a long way to go to reach the limit of plant and animal production. Increasing attention must be directed toward the solution of the very complicated social and economic problems which the national and international events of the past few years have pushed markedly to the front. They will vitally affect the agricultural well-being of the nation and of the state, unless satisfactorily solved.

These are not simple problems but I believe they can be solved by time, industry and patience, if men of ability, training, and experience can be set to the task. It will be a real test of our civilization as a nation, if, with the help of scientific research and statesmanlike vision, these problems can be worked out by the democratic route, with the cooperation of the states and of large and small groups in the nation's population. We must not forget, however, that undue haste often means large waste, nor should we overlook the admonition, "Be not weary in well doing, for in due season ye shall reap if ye faint not." This is a long-time task.

EVOLUTION OF AN AGRICULTURAL POLICY FOR MONTANA

Department of Agricultural Economics

Along the road of an unfolding knowledge of the agriculture of an area, based upon investigation and experience, a more complete view of its resources is obtained and consequently some policies for attaining the maximum welfare of the people using these resources begin to form.

Scientific research pries into unknown recesses, brings to light facts, and points out new processes whereby the difficulties of living may be decreased. Individual experience does not improve the welfare of the body politic to a great extent, but when the experiences are summarized and analyzed against the background of the scientific findings they become a part of the foundation upon which future development may be built. In the following discussion an attempt will be made to show something of the shifts in the use of land which will probably be advisable from the standpoint of local adaptability

of natural resources and also from the competitive position in the nation as related to the type of agricultural production possible in the state.

The best economic use pattern which can be worked out for land must rest upon the natural resource and should consider what economic development has been superimposed upon it. From this point of departure Montana citizens may anticipate some of the shifts which would be to the advantage of the area in the light of the economic development in the nation and in the world. When this shift has been anticipated all possible facts should be brought into play to facilitate reaching the highest level of return for the citizens of the area.

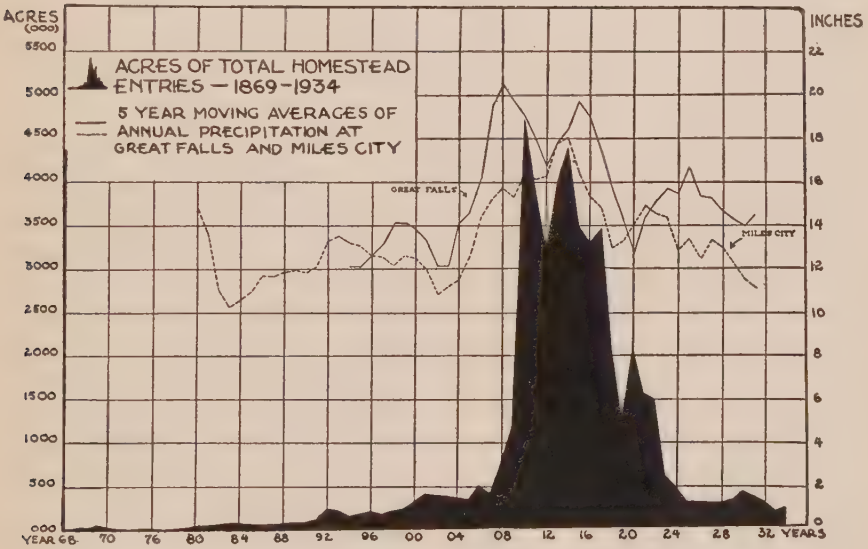

Figure 1.—Influence of precipitation on homestead entries

LAND SETTLEMENT

Settlement of the dry farming areas in Montana came as the last frontier lands in the United States were becoming scarce, and during a period in which Montana had more than normal precipitation. (See figure 1). During and immediately following this period of settlement the war needs and prices and postwar optimism tended to promote a continuation of occupancy. This was aided by a favorable

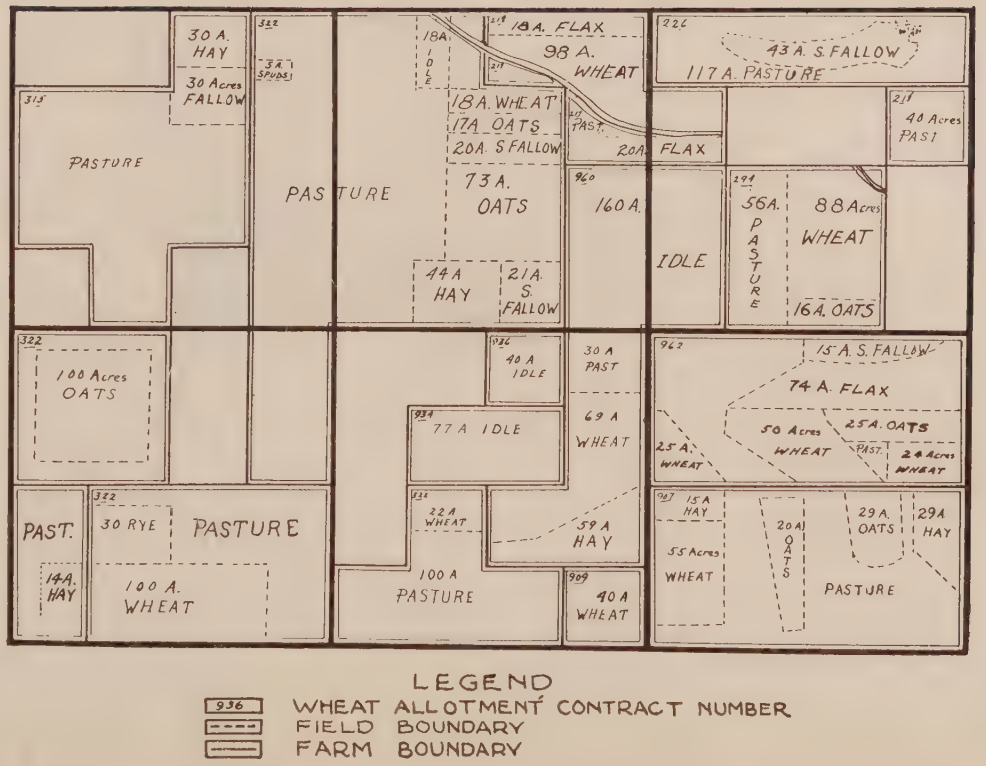

Figure 2.—Method used in mapping 1933 use of land in wheat allotment.

weather cycle, good crops on virgin soil, and the development of mechanical equipment well adapted to dry-land farming. The effect was to settle areas not well adapted to cropping under average conditions and especially unprofitable during a period of contracting market and lower prices for farm products. The problem before us is to readjust land use to the new economic conditions and prospects.

GATHERING AND ANALYZING FACTS ON LAND ADJUSTMENT

For many years the Experiment Station has been collecting information relative to farm and ranch operation and development. Careful examination and interpretation of this material with particular reference to needs and possibilities of adjustment, yield much valuable information. An illustration of this work is the assembling and analysis of information contained in the applications for wheat allotment contracts which were started in December, 1933. As the work progressed related material was added, or correlated, to give a more nearly complete picture of the problems of land use and of needed adjustments. This information covers about 94 per cent of the areas in the state which produce wheat and is a good picture of dry-farm operations. A record of wheat production covering a period of from three to five years between 1928 and 1932, and a complete record of land use on these farms for 1933 were available in this material.

Township maps of the state on a scale of three inches to the mile were made of this 1933 record (figure 2). These maps show location and size of farms, acres in cash grain, feed grain, hay, pasture, and idle land. They also show relative location of various types of land use and are a valuable guide to possible adjustments toward a more economic use of resources. A tabulated record of the production of each farm, arranged in township groups, is used to supplement these maps. Table 1 shows such a record, giving the acres seeded, acres harvested, percentage abandoned, bushels per acre, and total bushels for the years from 1928 to 1932. It also shows percentage of leased land, percentage farmed, percentage idle, number of farm units, and acres and percentage of land in various crops.

Maps similar to the Teton County maps, which show the location and use of land (figure 3), the 5-year average of the number of acres seeded to wheat and also the number of farm operators per township (figure 4), and the average yield per acre and the average number of bushels produced by each operator in each township (figure 5),

TABLE 1.—TOWNSHIP SUMMARY SHEET SHOWING WHEAT ALLOTMENT DATA FOR YEARS 1928 TO 1933, INCLUSIVE
5 Years. Teton County, Twp. 26 N., Range 5 W.

Wheat	Acres seeded	Acres harvested	Per cent abandoned	Bushels	Yield per seeded acre	Yield per harvested acre
1928	4,642	4,641	.03	94,299	20.31	20.32
1929	3,544	3,544	—	50,043	14.12	14.12
1930	2,907	2,887	.69	35,181	12.10	12.19
1931	2,335	2,265	3.00	24,016	10.29	10.60
1932	2,704	2,634	2.59	27,720	10.25	10.52
Totals	16,132	15,971	1.00	Acres 13,673	Leased acres 12,593	Per cent leased 92.10

	Acres seeded	Bushels	Average per acre	1933 total acres	Farmed acres	Per cent farmed	Per cent idle
3 Yr.	7,946	86,917	10.94	13,673	8,154	59.64	4.42
4 Yr.	11,490	136,960	11.92				
5 Yr.	16,132	231,259	14.34	Number of units 52		Number of operators 42	

	Wheat	Mustard	Flax	Oats	Barley	Rye	Hay	Fallow	Idle
Acres seeded in 1933	2,819	46	772	943	97	7	1,777	1,693	377
By percentage	34.57	.56	9.47	11.56	1.19	.09	21.79	20.76	

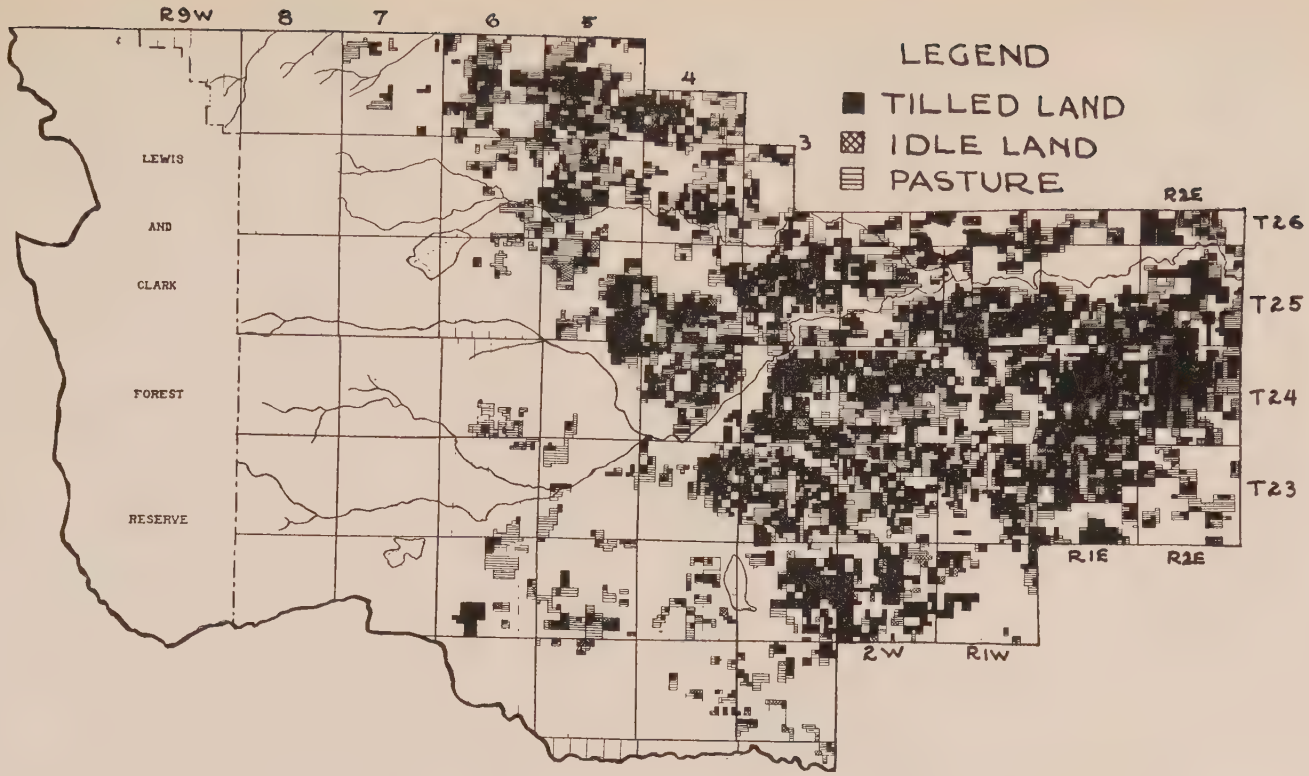

Figure 3.—Map of farms in Teton County showing tilled land, idle land, and pasture land (areas not designated may be in any of these classes).

have been prepared for each county from the farm and township data. Similar maps were prepared showing the number of beef cattle, dairy cattle, and horses for each minor civil division and for every county in the state. Maps showing the total number of sheep by counties only have been prepared.

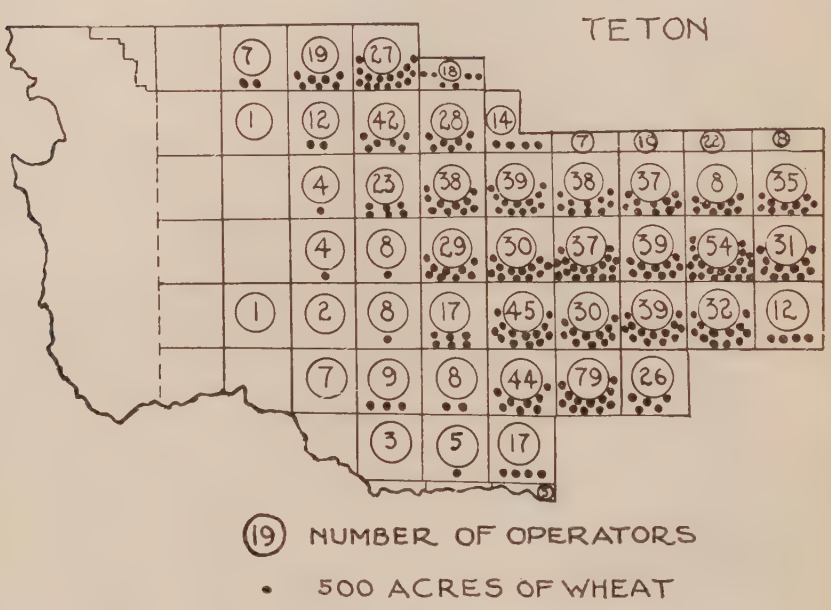

Figure 4.—Map showing number of operators and acres of wheat per township.

The census data of 1930 when analyzed for the state, show 2,644,-300 livestock units in the state while there is range and pasture for 2,584,689 units for a 9-month grazing, and hay for 3,623,298 units for a 3-month feeding period. This indicates the need of careful adjustment in the livestock program if feed resources are to be efficiently used and losses avoided.

In analyzing the application of possible adjustments to a given area the above material has been coordinated with (1) the soil surveys and land classification, (2) the United States Geological Survey and land classificiation, (3) the long-time weather records from the Weather Bureau, showing averages and departures from normal, and (4) the classification of land ownership. In addition studies have been made of the tax status of land, farm management and costs, of records of relief cases, of seed loans, and soil erosion.

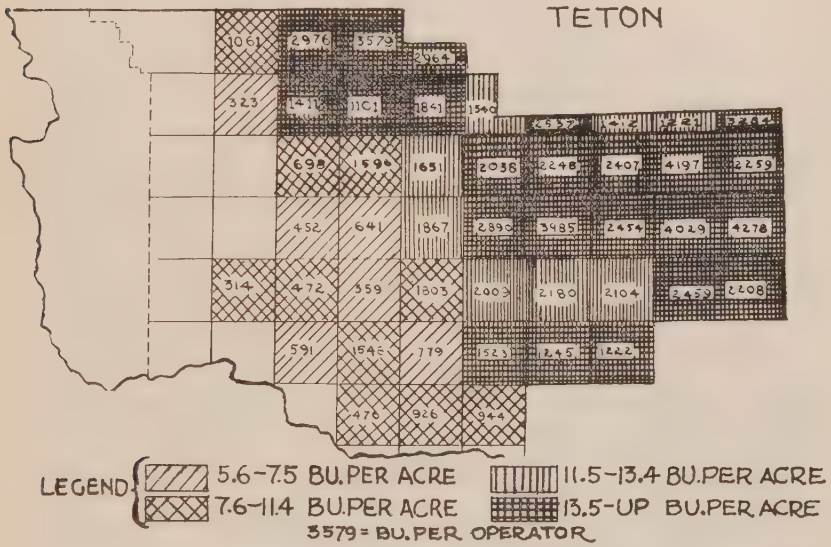

Figure 5.—Map showing wheat production per acre and bushels per operator.

Wheatland County offers a good example of one type of maladjustment. Early stock ranches were located along streams and near mountains to control the water and thus to control the adjoining range. In the decade from 1900 to 1910 some trial farming on dry land indicated good returns so that practically all of the tillable land, which had been used for grazing, was appropriated for farm use.

Time proved that most of this area would not return a living on the basis of crop production and most operators moved off the land. Parties who loaned money to this adventure acquired title to considerable land during this transition, and now 23.6 per cent of the county

is owned by corporate groups and 17.6 per cent by individuals not residents of the state. Figure 6 shows that resident ownership of Wheatland County is largely along the Musselshell and American Fork rivers and near the mountains. This is the old stock ranch land. Land owned by nonresidents and by corporate groups yet remains, to

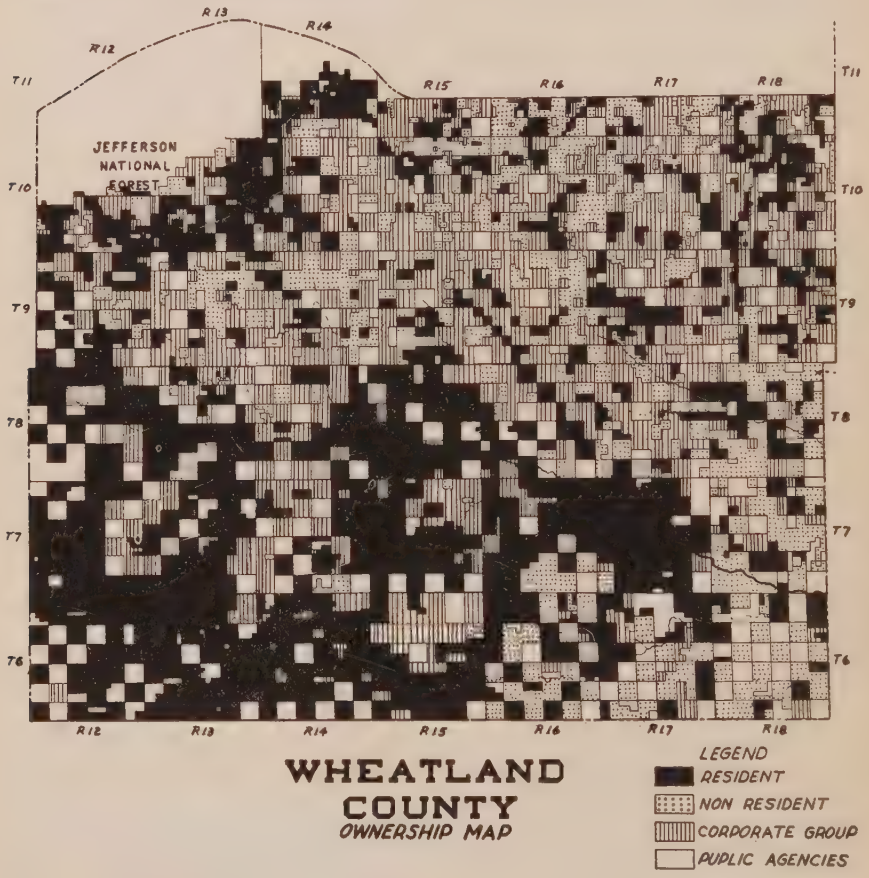

Figure 6.—Map showing land ownership in four classes.

a large extent, an investment only. Much of the land was acquired through an adventure in farming and as a result a large investment is involved, while the tax rate remains the same as for agricultural lands. As a consequence the lease rate is high with much land not leased, while the range is largely uncontrolled, so that a very un-

desirable tax situation has developed (figure 7). In this county 42.47 per cent of the taxable land was delinquent in 1933.

In many cases the need for adjustment is so great and the type of adjustment so clearly evident that definite recommendations on procedure can be made. In other cases much study will yet be necessary. Any program should be flexible. It is quite possible that

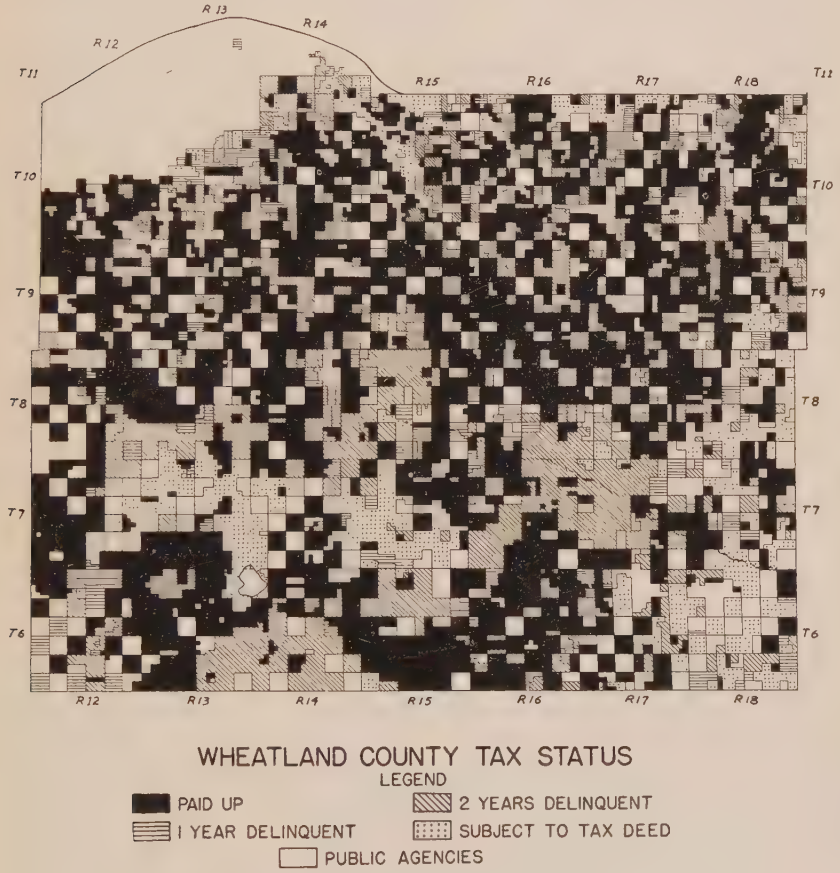

Figure 7.—Map showing tax status.

one major adjustment for the Great Falls area should be the establishment of a flexible program, whereby more operators can continually adapt operations to changing conditions.

Major adjustments indicated from the studies are: (1) Control of range lands, abondoned farms, and water supply; (2) proper balance between farms and range; (3) efficient use of land resources; and (4) a community pattern which will give better social service at a reasonable cost.

Land control.—Twenty-five million acres of Montana land are uncontrolled or held under a very unsatisfactory type of tenure. This unappropriated and abandoned or semi-abandoned land is now largely a liability instead of an asset, not only to the community but also to those endeavoring to use it; whereas, properly managed, its products would be of real value to individuals, the state and the nation. It is probable that there are classes of land and of conditions surrounding it which make private ownership impracticable or undesirable. National ownership and community management and use, under supervision, are indicated as a desirable alternative. Such ownership and supervision can be used to stabilize surrounding communities, maintain feed supplies, prevent range damage, and control water runoff. Community management should give free outlet to individual initiative and cooperation. Under such a system stock watering places may also be developed and some irrigation established, making possible range conservation and improvement.

Balance between farm and range.—The tendency among nations to be self-sufficient has its counterpart in states and in enterprises within states. There is at present a tendency among farmers and ranchers to talk and think of segregation of various enterprises, such as stock units, grain units, irrigation farming, and hay units in livestock areas. Such plans will lead to less efficinet use of the land resources. Much of the farming land of the state is interspersed among grazing areas. These should be attached to the farms, thus making more efficient units. Within the grazing areas are also tracts adapted to feed production and in many cases to grain. In allocating the use of pubicly controlled land careful consideration should be given these factors.

Efficient use of land resources.—Because of the time of settlement, market conditions, lack of knowledge of soils, various types of government assistance, and present changed economic conditions, much land is being used for purposes to which it is not adapted. Every effort should be made to assist in an adjustment which will correct this condition. Purchase programs, credit policies, production ad-

justment programs, and educational facilities can all be of assistance. Perhaps zoning will be justified at an early date.

A community pattern which will give better social service at a reasonable cost is imperative. In any land use program, not only must the needs of the individual farmer be considered but also those of the community. Such a program must visualize an attractive and desirable community pattern while securing a proper balance in the use of land.

A more diversified use of land.—The national agricultural adjustment program and Montana's adjustment policies are undertaken in an effort to get land into its best use and thus reduce costs, prevent overproduction, and conserve natural and human resources. Since the per capita consumption of food is limited and the export market is shrinking, it is probable that for the nation approximately 75 to 100 million acres of land of lower grade, or that poorly situated, or subject to erosion, will be retired to less intensive use.

Production of wheat at a profit seems to be limited to the better grades of land, though there is probably room for some expansion in what is classed in census reports as general farming. Specialized crops might be increased on all the better grades of farm land. Large areas in some sections of the state might be used in providing opportunity for recreation—summer vacations, hunting and fishing, summer homes and boys' and girls' camps. Such enterprises may fit into many farm or ranch operations without much interruption to the regular farm work. A report submitted by the Forest Service shows that 18 ranches in or near the Absaroka National Forest had a total of 2453 people spending 17,521 days as their guests in 1934. If 15,000 days were paid for at the rate of $5 per day the income would be $74,000. This contributes to a higher living standard instead of to surpluses, and also invites people to spend less time in productive competition.

IRRIGATION IN MONTANA

In 1929 about 28 per cent of the acreage in farms in Montana was irrigated. With a total of 47,495 farms in the state, some 11,925, or about 26 per cent, were irrigated. The area actually irrigated in 1929 was 1,595,000 acres. The value of the irrigated farms in 1929 was $190,057,936, or about 36 per cent of the value of all farms.

Irrigation development in Montana began with the agricultural development. The United States Census shows four irrigation enter-

prises organized prior to 1860 and 305 enterprises started between 1860 and 1869. During this early development, the water was appropriated by individuals directly from rivers and streams. Later, small projects were organized by irrigation companies to store water and build canals. Still later, irrigation development was fostered through federal and state legislation which made possible the creation of irrigation districts and project development under the Carey Act and federal reclamation acts.

Beginning about 1919 there was an increasing interest in irrigation development. Part of this interest appears to have been a result of the relatively dry years beginning in 1917 and the war prices for farm products. In part, the development apparently was financial promotion, rather than an irrigation development. Many irrigation districts created during this period never made any progress. Over thirty districts, created between 1919 and 1922, survived only a few years or were never started.

There are four federal reclamation projects in Montana, comprising over 300,000 acres of irrigible land. These projects have developed slowly and some are still in the development stage. While most of the early irrigation development in the state has proved successful, later development has been very slow and unsatisfactory.

Analysis of Montana's irrigation problems.—The analysis of Montana's irrigation problems began several years ago with studies of three federal reclamation projects, which were undertaken to obtain a physical and economic inventory of the areas, analyse causes for the relatively slow development, and suggest a basis for future procedure. Some of the difficulties have been caused by the failure of farmers to obtain an economic unit. In some cases the units have been too small and in others far too large. There was little or no differentation with varying climate, soil, topography, and markets. Another study was started, therefore, to analyse the climatic and other variations between Montana's major irrigated areas and to recommend economical size units and production program for each major area. The economic limits to cost of water are also being analysed. These studies have progressed far enough to give a basis for resettlement procedure under the rural rehabilitation program.

Rural rehabilitation.—It is estimated that Montana has about 2,000 misplaced and stranded farmers, located chiefly in the eastern part of the state. Little thought was given by the homesteader to the

various factors which affect his success, nor had any provision been made for studying the soils, climate, or crop possibilities and limitations. The result was that any and all lands were occupied regardless of location and quality. Moreover, the homestead laws limited farm entries to 160 or 320 acres of land in these dry areas when a section should have been the minimum. This lack of sound study of these problems, accentuated by years of drought, insect pests, and soil blowing, has led to widespread tax delinquency, low living standards, and in some areas to wholesale land abandonment.

The "stranded" farm population is a burden upon society and is contributing to further tax delinquency, in that other farmers are prevented from acquiring economic units. The Montana Rural Rehabilitation Division of the Emergency Relief Administration is actively engaged in carrying out a program of rural rehabilitation in the state. Generally resettlement must be made on irrigated land. To carry through this program, a physical, economic, and social inventory of all present and potential irrigable areas in the state is being made, and also for each an analysis of farm organization and management problems. The economical size of unit is being determined for each area, as well as the cost of land and water. A careful analysis of production and marketing organization will also be made to determine ability to repay.

A comprehensive analysis of Montana's present and potential irrigation development is being carried forward to show the present situation with respect to ownership of water and adequacy of present water supply; potential irrigation development, both from the water and land standpoint, farm organization and management practices by major type of farming areas; production of irrigated crops, as they fit into a state, regional, and national land use and comparative advantage pattern; availability of resettlement possibilities for Montana's stranded agricultural population, together with an analysis of cost and income factors; the present balance between the range livestock industry and irrigation development, and the impact and interrelationships of proposed changes in land use pattern and irrigation development; the present social service structure in irrigated areas and the effect of proposed development on such structures; finally, to show the place of irrigation resources in Montana's future development.

THE RANGE COUNTRY AND ITS USE

Livestock production in Montana, since its beginning in the late '80's, has undergone rather extensive shifts both as to type and volume. It is practically certain that further new developments in this field will occur during the next decade. Probably these coming changes will be in the direction of greater stability and a better use of the resources in the state upon which livestock production depends. These changes, both as to the type and the volume of livestock production, will come from a demand for the better use of the range and hay lands and for a type of ranch organization, of quality of production, and of rural community life, that will give the greatest stability in furnishing the nationally needed supplies of food and fiber materials.

Control of range lands.—There are now about 65,000,000 acres of usable grazing lands in the state. Of these approximately 10,000,000 acres are represented in public domain and county lands, 40,000,000 acres are privately owned, 5,500,000 acres are Indian lands, 7,000,000 acres are national forests and there are 2,500,000 acres of state lands. A study of the ownership and use of the privately owned grazing lands shows that about one-half, or 20,000,000 acres, is used by the present stockmen of the state on a basis of short term and uncertain lease tenure. If there can now be a change in the ownership or tenure of these lands it will permit better management and control on the part of their present users.

Recent state legislation affords a means of setting up cooperative grazing districts to handle these lands. These permit a management plan which will give a better seasonal use in grazing and also in regulating the rate of use for maintaining or improving their carrying capacity. The present and proposed activities of the grazing administration under the Taylor Act will afford similar cooperative development of management policies on the public domain. The land-buying activities of the Land Policy Section may also afford such a constructive policy by consolidating the ownership and control of the low-grade farmed areas of the state. This service may eventually be extended to some of the state range lands where the land ownership and use pattern has been rendered problematic by a considerable amount of interspersed farming development and absentee ownership.

A change in the control of county tax title lands, to give them a more definite management policy, may come through the cooperative activities of users, either through the State Association districts

or through the present tie-up of the state grazing district law with the administration of the Taylor Act. In some cases these lands are being sold to the Land Policy Section of the Agricultural Adjustment Administration. The ultimate purpose of all these activities will be to get away from the highly competitive use of the "open" and leased range land and to formulate constructive management plans for the development and use of such lands.

It now appears probable that there are certain types of land and certain areas in the state for which constructive management and use policies can be realized better through public rather than private ownership. This is likely to be true of the lower grade range lands. Such lands have in the past had a capitalization, a debt structure, and a tax load, which was not commensurate with their productive capacity as compared with the better lands. This has no doubt been one of the forces contributing to the tax delinquency and mortgage foreclosures on such lands. In other words, it has appeared that these range lands have been submarginal for private ownership. It may also be caused by the fact that the investment in fences, buildings, and other improvements, has borne too high a ratio to the value of the lands, which can be used economically only in large blocks with a minimum of such improvements. When these ranges have deteriorated as pastures, then under public ownership, through a long-time conservation and a deferred use program, their productivity may be restored. When again brought into use, however, provision should be made that part of the revenue from these lands should be returned to the area to support necessary local public service.

Range lands and winter feed production.—A study of the economics of range livestock production and ranch organization in Montana has been made by the Experiment Station covering the years from 1928 to 1933, during which the operation of some two hundred ranches, both cattle and sheep, was studied on the basis of their recorded data. This study showed that for the state as a whole, the average grazing period is at present 8½ to 9 months, and the winter feeding period ranges from 3 to 3½ months. The historical record is that in the early days of the range livestock industry of the state, the winter feeding period averaged considerably less than this. The production of additional winter feed has been made necessary through the greater number of livestock and the reduced carrying capacity of

the range. Statistical information indicates that the acreages of hay in the state have increased rather sharply since 1920.

The forage reconnaissance studies and the judgment of ranch operators, both indicate that in 1933 many of the range lands of the state were 50 per cent or even less of their potential carrying capacity. Table 2 shows for 1933 the probable carrying capacity of the range lands and the wintering capacity of the hay and forage

TABLE 2.—MONTANA LAND ANALYSIS RELATIVE TO CARRYING CAPACITY OF GRAZING LANDS

Kind of land	Acres of usable grazing	Carrying capacity in animal months	Carrying capacity for 9-month season	Percentage of total forage resource
Public lands[1]	9,420,255	1,177,532	130,937	5
Private lands[2]	40,000,212	12,000,063	1,333,340	52
Indian lands[3]	5,523,130	3,024,085	336,022	13
National Forests[4]	7,105,870	1,163,110	129,239	5
State lands[5]	2,773,758	1,395,732	155,087	6
Grazed crop land[6]	6,870,196	4,419,817	491,110	19
Total	71,690,421	23,180,339	2,575,735	100

[1]Montana Agricultural Experiment Station data. [2]1930 census data of land in farms, plus estimated averages of abandoned farm lands and unaccounted for grazing lands. [3]Indian service contact. [4]Government grazing report. [5]1930 Land Commissioner's report. [6]Including grazing on permanent meadow land; "Montana: Resources and Opportunities," 1933.

resources. These estimates indicate that the carrying capacity in 1933 of all range lands in the state would be approximately 2½ million animal units on the basis of a 9-month grazing period. The animal unit used here is the equivalent of a mature cow (4½ sheep being considered the equivalent of one unit). The livestock population of the state as of 1933 was approximately 2,700,000 units. In other words, the state as a whole was stocked above its normal carrying capacity to the extent of about 10 per cent for an average grass year, under our present system of range land control and use.

Range studies and the judgment of practical range operators seem to indicate that the carrying capacity of these range lands under ideal management could be increased to about 5 million animal units on the basis of a 9-month grazing period, or practically doubled. The acreage and production of hay and other roughage in the state, on the best statistical information available, shows a wintering capacity for a 3-month feeding period of approximately 3,600,000 animal units, or more than our present livestock numbers. If the ideal in maximum carrying capacity of our range lands were attained, and the grazing

period could be extended to 10 months rather than 9 months, then on the available statistical data the carrying capacity of the range would be approximately 4,500,000 units.[1] On the other hand, on the present production capacity of hay and other roughages for two months feeding of cattle, sufficient feed could now be produced to winter 5,500,000 animal units. This is more than the range could provide for under a 10-month grazing period, even under ideal conditions of range management and use.

If we could achieve a shift to a 10-month instead of a 9-month grazing period, it would mean a lowering of the production cost to the extent of about $1.25 per animal unit for all livestock produced in the state, and very materially strengthen the competitive position of our range livestock production.

The recent trends in range cattle production show an increasing proportion of cows in the cattle population of the state. With this has come an increased marketing of younger animals and a lower percentage of the mature. There are, however, certain areas in the state which are well adapted to steer production because of the type of range or water limitaitons. From such areas a certain proportion of mature, fat cattle could be marketed. Increased competition from other producing areas must be met by improvement in quality and uniformity of the Montana feeder cattle, and by improvement in grading and marketing methods.

THE TASK OF CROP PRODUCTION

Department of Agronomy

In a program of "reshaping Montana's agriculture" the Agronomy Department considers that two of its principal functions as a research agency are to make investigations which will result in classifying agricultural lands as to their proper use, and to conduct studies which will enable farmers to use the various classes and grades of agricultural land most economically.

Classifying agricultural lands.—The soil surveys provide the basic information needed in separating agricultural land into "farming" and "grazing" land, and these in turn into various grades based upon productive capacity. These surveys are progressing as rapidly as time and funds will permit. Since July 1, 1921, the Agronomy De-

[1]This would be the equivalent, say of 2,000,000 head of cattle, 8,000,000 head of sheep, and 500,000 head of horses as compared with the 1933 estimated population of 1,400,000 cattle, 4,000,000 sheep, and 380,000 horses.

partment, in cooperation with the United States Bureau of Chemistry and Soils, has completed the field work in connection with a soil reconnoissance in twenty-three counties in northern and central Montana, totaling approximately 38 million acres. Detailed soil surveys have been made in seven of the larger irrigated areas, involving approximately 2,200,000 acres. Data thus obtained, when combined with information on forage cover and historical yield, provide a basis for separating the farming land from the grazing areas and designating the grades of each.

Economical crop production.—The second major responsibility of this department is to determine how to produce most economically the maximum yields, whether the land be used for farming or for grazing. This does not necessarily contemplate any larger total production, which will contribute to present surpluses, but looks forward to finding new varieties and devising new methods that will give production at a lower cost per unit, thus enabling the farmer and the rancher to meet competition in the future more successfully.

Planning a more stable agriculture.—A sound plan for the use of Montana's agricultural lands undoubtedly will call for a reduction in the area now used for crop production, with a corresponding increase in the area to be used for grazing. Cropping will be confined to the better lands where the risk is lessened and the response to improved methods is greater. These better lands will also give a more adequate and dependable supply of forage and grain as feed for livestock. The increased safety from cropping the better lands and the added protection from larger feed reserves for the stockman will do much to place Montana's agriculture on a more permanent and profitable basis.

Reducing the cost of production.—Agronomic experiments show that better yields of the more important field crops may be obtained without a proportionate increase in the cost of production. Adapted grain and forage crops have been introduced, selected, tested, and made available by the department which show that superior yield is possible at only a slight additional expense for the seed and the harvesting of the extra yield. Varieties of wheat with higher protein content, increased winter hardiness, and greater resistance to smut and other diseases are the products of plant improvement studies. Varieties of oats have been developed with increased capacity for yield and with improved color and plumpness of grain, making them

more acceptable to both the farmer and the cereal mills. Brewing barleys have been tested to determine those best adapted for production in the irrigated valleys.

Increasing yields under irrigation by improving the cropping system.—Irrigated rotations have demonstrated beyond question the advantages of including a legume in the cropping system. Averages of the past nine years at Bozeman show increases of over 30 per cent for potatoes, 50 per cent for barley, and 52 per cent for wheat when grown in rotations containing three years of alfalfa, as compared with continuous cropping to these same three crops.

Barnyard manure, when available, will increase crop yields sufficiently to make its use decidedly worthwhile, especially if used in connection with, or to supplement, leguminous crops. In a rotation on

TABLE 3.—COMPARISON OF CROP YIELDS

Crop	Minimum yield 1934	Maximum yield to date	Difference
Potatoes, Rot. 42 (bu.)	42.6	321.1	278.5
Barley, Rot. 33 (bu.)	16.7	52.5	35.8
Flax, Rot. 30 (bu.)	8.2	22.3	14.1
Spring wheat, Rot. 25 (bu.)	14.7	60.9	46.2
Red clover, Rot. 41 (t.)	1.1	4.9	3.8
Alfalfa, Rot. 42 (t.)	2.8	5.2	2.4

the agronomy plots at Bozeman, which included three years of alfalfa followed by one year each of wheat, potatoes, and barley, in the order named, the total production of the alfalfa per year has averaged 4.67 tons of hay per acre. In another crop rotation which was identical except for the application of ten tons of manure per acre to the wheat stubble prior to plowing for the potatoes, the average annual production of alfalfa was 5.57 tons per acre, and the advantage of 0.9 ton, or slightly more than 19 per cent increase, was due to the manure applied. The ten tons of manure applied once in six years to the rotation also increased the yield per acre of barley 5.5 bushels, of potatoes 80.5 bushels, and of wheat 6.2 bushels for each year.

An ample water supply needed.—Crop yields on the irrigated farm are very dependent on an ample water supply. The recent series of dry years, which culminated in 1934, brings this home very forcibly. Table 3 shows the crop yields in 1934 as contrasted with the previous years when the rainfall and irrigation water were ample.

If we assume that the shortage of moisture was the principal factor in reducing crop yields on irrigated land under the conditions of

these experiments, the fact that the total crop production in an area such as the Gallatin Valley would have been increased in 1934, with an adequate supply of irrigation water, becomes obvious.

Value in irrigated pastures. — Experiment and observation throughout more than 40 years by the Montana Station have demonstrated the value and adaptability of irrigated pastures. When seeded to grasses adapted to the area and irrigated adequately during the growing season, with an occasional top dressing of well-rotted manure, these irrigated pastures have maintained a large carrying capacity and have given large returns in livestock products. With the further development of irrigation in the state such pastures should be an important and valuable factor in livestock production.

Figure 8.—The two bundles at the left show the beneficial effect of treble superphosphate when applied to alfalfa.

DISCUSSION OF SOIL PROBLEMS

Department of Chemistry

In a new agricultural area such as Montana, one would not expect soil deficiencies. But because of Montana's location at the top of the nation's drainage area, many places are deficient in mineral elements necessary to the full development of plant and animal life. The dry climate of much of Montana has resulted in a limited amount of humus and nitrogen in the soil. The Chemistry Department has been endeavoring to locate the deficient areas and point out methods that will overcome these lacks in the soil.

Alfalfa—Studies of the effect of phosphate fertilizers on the yield and phosphorus content of forage crops have been carried on in conjunction with the studies of the phosphorus-deficient soils of the state. The results this year confirm those of former years and show conclusively that the yield of alfalfa grown on many soils in the state can be greatly increased by applying a phosphate fertilizer. This increased yield is accompanied by an increase in the percentage of protein in the alfalfa, thus increasing its feeding value. The quality of the alfalfa is also improved from a mineral standpoint. Figure 8 shows the beneficial effect of treble superphosphate when applied to

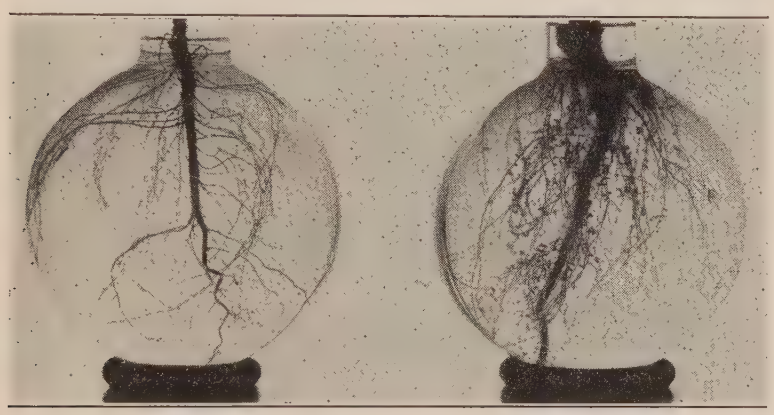

Figure 9.—Roots from average sweet clover plants. The root system at the left was grown on unphosphated ground and that at the right on phosphated ground. Phosphate has greatly favored the development of nodules and thus the fixation of free atmospheric nitrogen.

an alfalfa field at the rate of 125 pounds per acre. The two bundles at the left represent the phosphated alfalfa, while the two at the right were taken from the unphosphated strip. The former were much taller, of a darker green color and not so well matured as the latter. The darker green color and retarded maturity of the phosphated alfalfa indicate that it had also been gathering more nitrogen than the unphosphated. Phosphate fertilizers apparently increase root development and nodule formation, which is probably one of the reasons why phosphate increases the rate of growth and retards maturity.

The results of studies in 1934 on one irrigated field show that phosphate increased the yield of the first cutting of alfalfa from

Figure 10.—Outstanding effect of phosphate on yellow sweet clover. Yield from phosphated portion, 3,100 pounds per acre; from the unphosphated, 774 pounds — an increase of 2,326 pounds per acre.

3,291 pounds to 3,504 pounds, a gain of 213 pounds per acre. The second cutting was increased from 2,583 pounds to 4,305 pounds, a gain of 1,722 pounds per acre, and the third cutting was increased from 1,677 pounds to 2,504 pounds, a gain of 827 pounds per acre;

Figure 11.—Malting barley often responds well to phosphate fertilizer. This field in Gallatin Valley yielded 40.1 bushels per acre with phosphate and 17.7 bushels without phosphate.

or a total gain for the season of 2,762 pounds per acre. Moreover, these benefits are not confined to one year as other tests show that the residual effect may be carried into the third and fourth following years.

Sweet clover.—The results obtained with sweet clover under irrigation are as striking as those with alfalfa. The phosphate fertilizer increases the rate of growth, produces a darker green color of the leaves, and retards maturity. Figure 9 shows representative samples of sweet clover roots and nodules from phosphated and unphosphated plants. Phosphorus stimulated both root growth and the number and

Figure 12. The sugar beets in the background were fertilized with treble superphosphate.

size of the nodules on the rootlets. This increased growth of both roots and nodules increases the nitrogen-fixing power of the plant and thus furnishes an extra supply for plant growth. The phosphate fertilizer appears thus to serve not only as a plant food but to aid in increasing the supply of available nitrogen, the element used in large quantities by all leguminous plants. Figure 10 shows the very great difference in growth of sweet clover from a phosphated plot contrasted with sweet clover grown on soil undoubtedly deficient in phosphorus.

Barley.—The results obtained from applying treble superphosphate at the rate of 125 pounds per acre to barley grown on irrigated land are shown in Figure 11. The bundle to the left was grown on the phosphated plot and illustrates distinctly the resulting increase in growth. The bundles were cut from equal areas of land. The yield on the phosphated plot was 40.1 bushels and that on the unphosphated plot, 17.7 bushels per acre, or a gain of 22.4 bushels. This is a very satisfactory gain without considering the benefit received from the residual effect of the fertilizer in the following years.

Sugar beets.—Figure 12 shows a beet field in Carbon County. The beets in the foreground were not fertilized while those in the distance received an application of treble superphosphate at the rate of 125 pounds per acre. No record of yields was obtained but the figure clearly shows that the phosphate improved the stand and increased the growth materially.

Figure 13.—The larger bundle of oats was produced on phosphated ground. Yield per acre with phosphate, 31.4 bushels; without phosphate, 22.7 bushels.

Oats.—Figure 13 shows two bundles of irrigated oats cut from equal areas and representative of the plots from which they were taken. The bundle at the left was from the phosphated plot and that at the right from the unphosphated plot. Treble superphosphate was added at the rate of 125 pounds per acre. The yield from the phosphated plot was 31.4 bushels and from the unphosphated plot was 22.7 bushels, a gain of 8.7 bushels per acre.

Wheat.—Treble superphosphate was applied at the rate of 125 pounds per acre on a test plot of dry-land Turkey Red winter wheat in Gallatin County. The phosphated plot yielded 31.6 bushels and the check plot yielded 19.7 bushels, a gain of 11.9 bushels per acre.

SUGGESTIONS FOR FRUIT AND VEGETABLE GROWING

Department of Horticulture

Montana presents many problems growing out of our northern location in the interior of the country, the altitude, the extremes of temperature both summer and winter, and the limited rainfall for most parts of the state. What orchard and garden crops and what ornamentals to grow is a major problem. The adaptability of varieties to the special climatic and soil conditions in the different parts of the state and the cultural practices that will produce crops of satisfactory quality are problems for further investigation. The skill of the plant breeder has been fully shown in the plants he has developed and adapted to new and extreme environmental conditions while retaining yield and quality. There is yet much to be done in this direction in Montana. Some endeavors in these directions are illustrated below.

Apples.—Montana is near the climatic limit for the growing of quality apples and the area where this is possible is limited. Experiments with commercial fertilizers have been undertaken in the endeavor to improve market quality. Six years of study and observation indicate that a combination of nitrogen and phosphorus consistently gave good yields and firm fruit with a very satisfactory color. The yield was not the highest nor the fruit the largest in size but the trees produced the most extra fancy fruit. Trees treated with nitrogen alone bore good apples and on the average the largest fruit. The color, however, was off and the fruit was rather soft with poor keeping quality. Phosphorus alone produced well-colored fruit but the yield was consistently below that from the combination of fertilizers and the fruit was small. This study indicates that in the Bitter Root Valley nitrogen gives good yield and size, while phosphorus gives firmness and quality; their combination gives the desired results.

Potatoes are an important crop in Montana, but medium to early maturing varieties are recommended. With a soil in good tilth and well supplied with humus, the addition of phosphorus in many cases increases the yield of potatoes and improves their maturity and handling quality. It also gives a distinct gain in the percentage of

no. 1 potatoes. In other words, more and better potatoes have resulted from the use of phosphorus in all areas where the tests have indicated a phosphorus deficiency in the soil.

Raspberries.—Studies with raspberries show that they may be grown in practically any section of the state provided the plants are protected in the winter. The yield of berries is increased by winter protection even in areas where the practice is not usually followed.

While such varieties as Ohta, Sunbeam, Latham, and Chief will prouce a partial crop without protection in four out of five years at Bozeman, with protection a good crop can be depended on every year. Without protection in 1934 Latham yielded at the rate of 2,207 pounds of berries per acre and Chief, 1,575 pounds. With protection Latham yields were increased to 7,709 pounds per acre, or a three and one-half fold increase, and Chief produced 6,100 pounds of fruit or nearly a four-fold increase. If such results can be obtained at Bozeman there are few sections in the state where winter protection of raspberry plants would not result in satisfactory yields. Bending the plants to the ground and covering them with soil was all the protection needed.

Tomatoes.—In many parts of Montana tomatoes cannot be considered a commercial crop. The season is too short to ripen much of the fruit. This handicap can be partly overcome and ample ripe fruit obtained for home use by early planting in a greenhouse or hotbed to get good growth before transplanting to the garden. The earliest ripe fruit will be obtained by careful handling of the transplants.

CONTROLLING INSECT PESTS

Department of Entomology

The primary object behind the reshaping of Montana's agriculture is to bring our agricultural activities into closer harmony with our environment. In other words, if it is possible for us to take into account more of the natural hazards as well as the advantages of our environment, then, over a period of years, our economic level will have been raised. In such a statement of the problem it is clear that, so far as anything we in Montana can do or are responsible for, our economic condition is the end product of what in the past has been a faulty alignment between our agriculture and our environment. The real problem, therefore, involves all the factors concerned in a safe and economic agriculture. Insects are one, and a very important one, of these factors.

Recurrent insect epidemics were the rule in Montana and not the exception even before the advent of the white man. There is little doubt but that the economic condition of the Indian inhabitants was greatly influenced by the two very closely associated factors of drought and insects. During periods of dry weather, crickets and grasshoppers would become so abundant that range grasses were destroyed over wide areas, resulting in the extensive migration of game animals to better feeding grounds or their actual death by starvation. The native tribes themselves could migrate along with their source of food but, on account of tribal enmities and slow methods of transportation, such migrations would be too limited for them to escape entirely the deprivations accruing from lack of rainfall and the inevitable insect depredation on what little grass remained.

IMPROVING INSECTICIDES

Much has been done in the introduction and cultivation of natural parasites to be used in the control of destructive species of insects. However, dependence for controlling insect pests must be placed largely on the use of various chemicals. An important problem for the entomologist, therefore, is to find the effective chemical compounds and devise better methods for applying them so as to secure effective control of a great variety of insects with the minimum of injury to the plants to be protected. When any material is applied to a plant, either as a spray or a dust, there are many physical and chemical conditions which enter into the results obtained. The fineness of division of the particles, the electric charges carried by them, the suspensibility, solubility, surface tension effects, all these play a part. Just lately experiments have brought out the importance of the acidity or alkalinity of surface waters used in spraying operations. The suspensibility of lead arsenate is affected to a marked degree by even slight shifts in the alkalinity of the water used. As there is a very close relationship between the ability of the material to remain in suspension in the spray mixture and the character and the amount of coverage obtained by that material on the fruit and foliage of the tree, this phenomenon is worthy of much attention. It has to do not only with the killing effects of the spray material but also the cost of the operation.

In order to protect the users of arsenical preparations from suffering losses of plants by the burning of foliage, arsenic compounds are sold on the basis of the water-soluble arsenic they contain. These

determinations are carried out in water which is quite acid in reaction. When the same lead arsenate, which had a solubility as low as one-third of one per cent according to that method, is mixed with water which is slightly alkaline—and most spray waters are alkaline—the solubility may be ten or twelve times that amount.

We have always believed that, except with some insect poisons derived from plants, it was impossible to find materials which would be very toxic to insects and yet rather innocuous to plants. That of course is one of the essentials of an ideal insecticide. In the case of some petroleum oils that idea has been overthrown by laboratory experiments in this department It has been found as a matter of fact that the purified oils, which are the safest for the plant, may at the same time be very effective in the destruction of insects.

IDENTIFICATION OF INSECTS

Hundreds of species of insects are sent in to us every year for identification. It is very easy to name most of them and furnish necessary information as to their harmful or beneficial character. Often, though, such is not the case and as an aid in this work a large collection of insects correctly named by the best authorities is maintained, An insect catalog is also being assembled which shows the distribution of all the species known to occur here, time of occurrence, and any economic significance they may have.

Especially useful is the insect collection when there occurs the sudden rise of a destructive and little known species of insect. Just as soon as its correct scientific name is ascertained, then all the information ever published anywhere in the country—or in the world, for that matter—becomes available. An excellent example of this was the discovery in Montana of Say's plant bug, or the grain aphis as it is also called. Its scientific name is *Chlorochroa sayi* Stal. Now there are dozens of other species which resemble this one very closely but have widely differing habits. In fact, some confusion of species would be very excusable. When a number of these bugs were sent in from Hill County in 1932 with the statement that they were causing severe damage to the wheat crop, it was easy to furnish all the known information as to the seriousness of the insect and the best remedial measures which had been worked out for it. Unfortunately, in this case, the only control measures as not very practicable in Montana and the Experiment Station is attempting to find some new method of destroying this pest.

Likewise in the case of the early stockmen, severe winters, drought, and the accompanying insect destruction of range grasses, meant the difference between well-fed stock going to an eastern market and accumulations of whitening bones in gullies and ravines where the half-starved cattle had made their last stand against the rigors of a severe climate and hordes of destructive insects which at that time could not be successfully combatted. The occurrence of insects in the times long past show that, at not infrequent intervals, insect depredations in this region implied catastrophic consequences. The same is true today so that insects may be said to constitute one of the major factors in any well-devised system of agriculture in Montana.

PREDICTING INSECT OUTBREAKS

The Montana Agricultural Experiment Station began to take cognizance of the damage grasshoppers could do to agriculture about thirty-two years ago when, in eastern Montana, hordes of these insects caused widespread destruction of forage plants. Other outbreaks have occurred through the years, which the department has studied carefully while devising and improving methods of control. The results of these studies and the development of organization plans so necessary to success in extensive campaigns with the establishment of confidence on the part of the farmers of this state that grasshoppers could be controlled, were of inestimable value in 1934, a year when without doubt the greatest grasshopper plague of modern times took place.

Prior to 1931 grasshopper outbreaks in Montana were predicted successfully from conditions the previous season but these predictions were general in nature. The remarkable thing about the 1934 infestation was that specific predictions were made for fifty agricultural counties in Montana and ready-mixed poisoned bait laid down in each county before the grasshoppers hatched. It was estimated in November, 1933, that 18,017 tons of dry bait would be needed in 1934. Actually, 16,254 tons were used, resulting in an error of less than 10 per cent. Had dry weather not stopped all poisoning in eastern Montana about July 1st, except in irrigated sections, the error would have been negligible. The north-central counties of Montana harvested some 27,000,000 bushels of wheat in 1934. This was accomplished, on the word of 90 per cent of the farmers themselves, as a result of the poisoning campaign in these most heavily infested counties. This, it is believed, is one of the best examples of planned entomological work based on sound experimental evidence.

This recent experience with grasshoppers is probably the best example we have of the value to be derived from the accurate prediction of insect outbreaks. Probably no greater service from an insect-control standpoint can be rendered the farmers of Montana than forewarning them of coming insect difficulties, and furnishing a practical remedial measure. In the past few years the Experiment Station has furnished such information on the pale western cutworm and the beet webworm. Work in progress is designed to perfect the methods now in use and to extend them to other destructive species. Some insects are present every year but others, like those just mentioned, come upon us unawares in damaging numbers and it is for such that prediction becomes of very great value. It is a scientific method of forestalling one of the hazards of our agricultural environment.

THE PROBLEMS OF PLANT DISEASE CONTROL

Department of Botany and Bacteriology

The Department of Botany and Bacteriology has for its main purposes (1) the investigation of plant diseases and their control; (2) the study of the ever-present poisonous plant problem, which is directly connected with the livestock and range management problem; (3) the identification and control of destructive weeds in crops.

Plant diseases and their control form a very complex problem, and one that is ever present because of changing conditions and the continual introduction of new crop plants and new diseases. Wheat bunt is a serious disease of wheat, which frequently causes a loss of over one million dollars per year to Montana farmers. Plant breeders are developing resistant varieties of wheat, but new varieties of the bunt fungus are frequently introduced and climinate the economic advantages of the new varieties of wheat. Continual investigation of this problem has been necessary in order to render service by identifying the many varieties of wheat bunt and recommending control measures.

Profits in dry-land wheat have steadily decreased as more and more of the land becomes infested with various root-rot organisms such as Fusarium and Helminthosporium. There is need for much additional work on these diseases to determine what particular organisms are causing the troubles, to learn their habits, and to develop methods of controlling the different parasites.

This department should enlarge the scope of its study of virus diseases of potatoes and include other crops in order to secure much needed information and fuller understanding of these diseases. Tomato yellows, probably the most serious disease of this crop in the western states, occurred for the first time within Montana in 1934. It is a virus disease similar to that causing the curly top of sugar beets, which is transmitted by the sugar-beet leaf-hopper (*Euttettix tenella* Baker). This curly top virus also attacks other crops such as garden beets, peppers, swiss chard, beans, and spinach. Some growers reported a loss of 50 per cent in yield of tomatoes in 1934. Should this disease become established in Montana, much study will be needed on control measures and selection of resistant varieties.

Results from plant selection for resistance to bean mosaic, a virus disease, indicate that it is possible to select strains of the Great Northern bean which are resistant to this disease and at the same time prove much superior to field-run seed, giving greater production, more even maturity, and an improved type.

The department has cooperated actively with the United States Department of Agriculture in the barberry eradication campaign since it was begun in 1917. The survey has now covered the entire state and over 40,000 barberry bushes and seedlings have been destroyed. To find the few remaining bushes, the field agents have enlisted the aid of the children during the past three years by presenting the story of black stem rust and the barberry in the public schools. To date this educational work has been completed in twenty-four counties. In this campaign Montana has been cooperating with twelve other wheat-growing states, which comprise an area of 1,050,000 square miles. As a result of the campaign grain losses due to black stem rust have been steadily reduced in the United States. This is shown by the decrease in average annual losses by six-year periods: for 1916-1921, 57,000,000 bushels; 1922-1927, 18,000,000 bushels; and 1928-1933, 3,500,000 bushels. During this period over 19,000,000 rust-spreading barberry bushes have been destroyed in the thirteen north-central state comprising the campaign area.

Within the past five years much progress has been made in the development and reorganization of the herbarium, which is owned jointly by the college and the station. From 1903 to 1929 it was slowly but steadily built up by collections made by the staff members. During 1929-30 exchanges were made with other institutions and over

5,000 specimens were added to the collection. In 1933 Dr. P. H. Hawkins, of Absarokee, placed his valuable collection, numbering over 10,000 specimens, in the herbarium, which doubled the number of specimens of flowering plants available for reference. The herbarium also includes over 12,000 specimens of fungi. The scientific records of all these specimens are of infinite value in tracing the history and distribution of a particular weed or a plant disease within the state.

During the same period, by the use of C. W. A. funds, with men working under the supervision of the staff, the herbarium has been reorganized with adequate card catalogs, accession numbers, etc., and the specimens have been filed by families according to De Dalla Torre and Harms. By these records and rearrangements the specimens are more readily accessible for reference and study.

A WELL-PLANNED AGRICULTURE MEANS A BETTER STANDARD OF RURAL LIVING

Department of Home Economics Research

Much of the work carried on by the Montana Experiment Station during the past years has been done to aid agriculture directly in establishing itself on a more profitable basis. Such investigations as the classifying of soils, and methods for improving the quality of livestock, grain, and fruit, or eradicating pests and disease have been designed to enable the farm to produce a better and more steady income. With the more recent development of an economic interest in farm problems, the ultimate aim of these varied activities has been enlarged to include the thought that the farm income should be sufficient to provide a satisfactory standard of living for the rural family. The Home Economics Department has, therefore, taken its place in this expanded program of the Experiment Station and devoted its activities to studying some of the factors that are involved in bringing about a more satisfactory standard of rural living.

What does such a standard of living cost? Through the cooperation of forty rural families living in various parts of Montana, it has been possible to secure household accounts over a period of one year, from which was determined the average annual cost for a medium-sized family when living on a satisfactory basis. In 1929-30 the average annual cash expenditure for a family of four persons (excluding automobile, savings, and investments) was $1,089. This study also showed how the family expenditures were distributed

among the items of food, clothing, house furnishings and equipment, operating expenses, personal needs and advancement.

What may the farm contribute to family living? In this same study, it was found that a well-planned farm could contribute much to the farm home. Of the total cost of living, 43.3 per cent was furnished by the farm, principally in food—meat, milk, eggs, vegetables and fruits.

How may the farm improve the quality of the food produced for family use? For several years this department has cooperated with the work in animal husbandry by testing the quality and palatability of lamb fed on varying rations. The results of such tests influence not only the quality of the family's food but may also affect the value of the commercial product.

Recently another cooperative study has been started in connection with the Horticulture Department, to test the quality and nutritive value—the vitamin and mineral content—of vegetables raised under varying moisture conditions. Vegetables are grown on dry land, and on plots watered by overhead sprinkling, by an underground wooden tile system, and by furrow irrigation. There are definite indications that the mode of applying moisture to the vegetables may cause variations in their flavor and texture as well as in their nutritive value.

How may the foods produced by the farm be advantageously preserved for family use? Many of the farm products used by the family are seasonal in nature. In order to utilize the material and make it available at other times of the year, some method of preservation must be employed, such as storage, drying, salting, canning, fermenting, or preserving. The relative merits of these methods, as they affect the palatability and vitamin content of vegetables, have already been studied to quite an extent by this department. Potatoes, carrots, rutabagas, onions, and cabbage have been tested before and after storage; carrots, peas, and corn, before and after canning; corn, after drying; cabbage and corn, after fermenting; and corn after salting Thus far, storage of vegetables, when well-done and feasible, gives the most desirable and nutritious product, with canning taking second place.

HOW HOME ECONOMICS RESEARCH MAY AID THE CONSUMER

The homemaker of today is usually the buyer for her household. The task is not as simple as it sounds for present conditions demand that she shall be an intelligent consumer, endeavoring to secure the best values for the money expended.

Since so few articles of merchandise carry a label giving a satisfactory description of their quality, the homemaker has been obliged to base her selections somewhat on guesswork, hoping that the purchased goods would fulfill her expectations. Such experiments often prove rather costly, so consumers are beginning to ask for reliable information that will aid them in their buying problems.

To supply such information, careful studies of these problems must be carried on, and this has brought about the development of home economics research laboratories in practically every state and in the Federal Bureau of Home Economics at Washington, D. C. The work in these laboratories is being conducted under four main divisions: (1) Housing and Household Equipment, (2) Home Management, (3) Food and Nutrition, and (4) Textiles and Clothing.

Research studies require considerable time but some results are already available that can give valuable assistance to the homemaker as she plans her purchases. There are reports on the relative merits of different types of washing machines, kitchen ranges (kerosine, gasoline, and electric), cooking utensils, refrigerators, and vacuum cleaners. Information has also been sent out concerning the buying of bedding (sheets and blankets), ready-made dresses, women's coats, and material for children's clothes.

The division of Food and Nutrition has received much attention and there are now many reliable publications giving the relative nutritive value, vitamin and mineral content of our food materials. The economics of food buying is also being studied and is drawing attention to comparative costs of canned goods in various sized cans, fruits of various sizes, and ready-to-mix products versus home preparations.

Home economics research is as yet in its infancy, but when the results of its extensive activities begin to reach the homemakers of the country, they will then be aware that there is an educational agency ready to give reliable and impartial aid to consumers.

SOME IRRIGATION PROBLEMS

Department of Irrigation and Drainage

Farm experiences in Montana, especially those of the past few years, have emphasized the great need for water conservation. Water is scarce in the state and every effort should be made to hold all of it possible on the land and in the soil. These experiences especially emphasize the need for further extension of irrigation farming. It is to the irrigated areas that the farmers, stranded in certain submarginal farming areas, are turning because of the stabilizing value of irrigation for the individual farmer, the community, and the state. Local, state, and national agencies are now unitedly advancing a program of irrigation development, not only creating new projects but working toward a more dependable supply of water for the older irrigated lands. The Department of Irrigation and Drainage is studying various problems relative to a more efficient use of water. Some of these are discussed below.

Use of flood waters.—Studies have been made of the experiences of a large number of farmers in storing flood waters by the use of diversion dikes and reservoirs, and by the construction of small dams to store water as a source of supply for livestock on the range. A large number of such dams are needed on the range where breeding stock with their young are pastured, as watering places should be available, usually not more than three to four miles apart.

The study shows that earthen dams may be built with little expense except the labor of the farmer and of his horses, but certain principles of construction must be followed if the labor is not to be lost through the failure of the dam. A bulletin has been prepared covering fully the points to be observed in building such dams.

Water wheels and pumps for irrigation.—In cooperation with the Department of Agricultural Engineering homemade water wheels and water-lifting devices have been designed for use where good land lies adjacent to large streams so that cheap power is available to pump water for irrigation. A homemade box pump has been designed for low lifts. A wide range of sizes is possible and the cost of materials is small.

Methods of irrigation.—To reduce the cost and increase the efficiency of irrigation on the older irrigation projects, studies have been made of different methods of applying water. The common plan of flooding from ditches is often wasteful of time and water, especi-

ally if the ditches are too small or are improperly located, whereas the border-dike method has been found to save labor in irrigating alfalfa or other hay crops, as it makes possible the handling of large streams by one man, thus saving water and giving more uniform irrigation. The corrugation method also saves time and water and the effective control of water. Its use is most practical for grain and row crops.

Available water supplies.—With further agricultural development in the state there is a definite turning toward irrigation and a recognition of the fact that the limiting factor of development in this direction is the water supply. It is important therefore that an inventory be taken of the dependable water supply to be found in Montana's rivers and streams. The area of land suitable for irrigation is far in excess of the supply of water available for diversion during the irrigation season. By knowing the water supply and the needs for irrigation, power, industrial and other uses, future development may be planned so as to use the water where it will do the most good. This department is assembling the facts about the water supply of the state.

Supplementing the measuring and cataloging of the stream flow available during the irrigation season, a snow survey of the mountain areas is being made to learn whether it is possible to determine early in the season how much water may be expected from any particular stream during the irrigating season. Such surveys have been successfully used in other states and in parts of Montana. It requires the collection of data over a period of years to deduce the relationship between accumulation of snow at the close of winter and the flow or runoff from any particular watershed. The facts accumulated along this line should therefore become more reliable and valuable from year to year as the volume of data increases.

COMMENTS ON FARM ENGINEERING

Department of Agricultural Engineering

The engineer uses the findings of science and the genius of the inventor to make products useful in the home, in the factory, and on the farm. The agricultural engineer utilizes science and invention to improve conditions for the farmer in order that he may increase his income, lessen physical fatigue, and have a richer and happier life. He interprets the farmer's needs to the manufacturer and passes on to the farmer information as to the use of the manufacturer's pro-

ducts. The power-operated washing machine replaces hand scrubbing of clothes. The vacuum cleaner replaces beater and broom; modern ranges, refrigerators, and heating plants afford methods of heat control that reduce to a minimum the amount of human energy necessary to keep the house clean and comfortable. Water systems and light plants have added a large measure of comfort for the entire household and have relieved the housewife of much drudgery.

The business and the home life of the farm are so closely associated that what affects one has a marked influence on the other. In no other walks of life are the earning of a livelihood and the living itself so intimately connected. Use of modern equipment in the farm home, besides adding comfort and reducing toil, may lessen the cost of hired help, thus affecting the farmer's income. The use of power machinery on the farm also has its effect on the work in the home. Consequently, the agricultural engineer's work affects both the home and business life of those for whom he works to a greater degree than the work of any other type of engineer.

Efficiency in production has been attacked as the cause of overproduction. If efficient methods were abandoned the farmer should be obliged to take a more round-about course in doing his work, thus increasing the cost of the crops he actually produces. The return to obsolete methods would destroy rather than save him from economic ruin, and would lower his living standard. The farmer's problem is to produce crops with the highest efficiency and economy and to adjust this production to the nation's economic needs.

As science has increased production and brought about in certain directions an apparent overproduction, it should now be called upon to help direct production in channels where the results can be used to better the living conditions of society. If all producing power were rightly directed, could not all the products of labor be utilized for the betterment of economic, social, and living conditions? Rather than lessen the application of science to our problems of production, should it not be increased so that the greatest possible development along these lines could be secured?

Opportunities for agricultural engineers to aid agriculture are many and varied. Some of these, already taken advantage of, are farm buildings surveys, wheat allotment surveys, farm electrification, soil erosion control, road construction, irrigation and water conservation, and drainage for mosquito control.

The agricultural engineer serves an industry whose factory consists of land and equipment to work the land and handle its products. Although only about one-fourth of the population are producers of agricultural products, they and the other three-fourths are consumers of those products. Thus the activities of the agricultural engineer in the national recovery program are not limited to a single class but affect the entire population.

The forces which have to deal with a proper balance between all the interests involved in the production, protection, transportation, processing, handling and consumption of agricultural products are of vital importance to the agricultural engineer. He should be capable of materially aiding in establishing that balance between the various interests which is so essential to rehabilitation.

Government agencies are endeavoring to classify lands and determine their best adaptations. The engineer comes into this picture to recommend or install improvements in cultural practice, in irrigation, drainage, erosion control, and in equipment for the best use of the land. His studies in this connection will aid in proper classification of the lands.

The engineer must develop mechanical equipment and methods to utilize the land in a profitable and economical manner, which means that the greatest possible efficiency must be attained. He is already engaged in many phases of this type of work, such as the application of machinery and machine methods to sugar beet production, the economic study of corn production methods, use of power in potato production, the effectiveness and the economics of land irrigation from the crop standpoint, the drainage of farm lands, the national soil erosion program, housing for both human beings and livestock, and the use of power and electricity on the farm.

THE PLACE OF LIVESTOCK IN A REORGANIZED AGRICULTURE

Department of Animal Husbandry

The work of the Animal Husbandry Department is carried on in various places in the state in order to study problems pertaining to the many phases of the livestock industry. Range herds of beef cattle are maintained at the Northern Montana Branch Station near Havre and the United States Range Station near Miles City. Herds of pure-bred beef cattle are maintained at the home station at Bozeman. Studies of dual purpose cattle are carried on at the Judith Basin

Branch near Moccasin. Bands of range sheep are maintained at Bozeman and at the United States Range Station. Experiments with hogs are also carried on at these two places. Herds of dairy cattle are kept at the home station and at the Huntley Branch Station. Studies with turkeys are conducted at Miles City. Feeding and fattening experiments with the various classes of livestock are conducted at all of these stations. This distribution of the work with livestock is desirable because of the size of the state and the variety of soil and climatic conditions found in the different areas. The results of some of the experiments conducted during the past year at the home station that have special importance to the livestock industry of the state are presented here.

RATIONS FOR FATTENING CALVES

In a 196-day feeding trial with three lots of 460-pound calves to determine the value of adding cottonseed cake to a barley and alfalfa ration and of substituting dried beet pulp for part of the barley, the following results were obtained.

Value of adding cottonseed cake.—The addition of ¾ of a pound of cottonseed cake increased the gains, the cost of gains, the degree of finish and the selling price. The cake-fed calves gained 0.15 of a pound more per day and were valued at 35 cents per hundredweight more than the barley-fed calves, thus showing a greater profit in spite of the higher cost per hundredweight gain.

Value of substituting dried beet pulp for part of the barley.—Feeding one-half dried beet pulp and one-half barley with alfalfa hay resulted in slightly slower gains but better finish. The greatest advantage in using dried beet pulp was in the elimination of bloat in starting calves on feed. Considerable trouble is generally experienced when calves or steers are started on barley. The calves in this lot were started on dried beet pulp, and after 28 days barley was gradually added until it made up one-half of the grain ration. The feed required per hundredweight of gain is shown in table 4.

EXPERIMENTS WITH DAIRY CATTLE

Rye as a grain feed for dairy cattle.—Two groups of 14 cows each were used in a 49-day feeding trial to compare rye with barley. One group was fed a standard grain ration which was one-half barley while in the other group rye was substituted for barley. The cows

TABLE 4.—FEED REQUIREMENTS PER 100 POUNDS GAIN

Lot	I	II	III
Ration	Alfalfa Barley	Alfalfa Barley Cottonseed cake	Alfalfa Barley Dried beet pulp
Alfalfa, lbs.	254.6	236.1	256.4
Barley, lbs.	492.7	464.1	234.7
Cottonseed cake, lbs.	——	34.4	——
Dried beet pulp, lbs.	——	——	279.3
Average daily gain	2.0	2.15	1.84

fed rye ate one-half pound more grain and 2 pounds more alfalfa hay per head per day than did the cows fed barley and gained 12 pounds more per head, but produced slightly less milk and butterfat. Samples of milk scored for flavor during the feeding trial gave the milk from the rye-fed cows a slightly lower score In a 98-day trial, rye was compared with barley as a grain for growing dairy heifers. There was essentially no difference in the gains made by the heifers on the two rations.

The conclusion from these tests is that the relative cost of the grains should determine which to use in the ration for dairy cattle. This conclusion is important because rye has proved to be the surest dry land grain crop.

EXPERIMENTS WITH RANGE SHEEP

The station has a band of 1000 breeding ewes which is used in the study of range sheep problems. The sheep are ranged as a band or unit on foothills in the spring and fall and in the forest reserve in summer. In winter the ewes are divided into lots of about 200 head each for comparing feeds and methods of feeding for wintering range ewes.

Summering ewes and lambs on the forest.—One of the most important phases of range sheep work is the study of management problems in the forest. A permanent allotment is set aside for the exclusive use of this band. Based on a thorough reconnaissance survey, a detailed management plan has been worked out by the Forest Service in an attempt to develop a plan for conserving and building up the forage resources of the forest. The ewes and lambs are weighed individually on entering and leaving the forest in order to obtain data on gains made under this plan of management. The time allotted for grazing in the forest is determined by the condition of the forage at the close of the previous season.

The time allowed on the allotment for the season of 1934 was 71 days. The average gain per ewe for this period was 7.92 pounds; for yearling ewes 20.37 pounds; and for lambs 28.6 pounds, or nearly one-half pound per head per day. The band entering the forest consisted of 938 ewes, 58 yearlings, and 1142 lambs. Sixteen ewes and yearlings and 6 lambs were lost during the season. The average weight per lamb was 73.3 pounds, or a total of 88.79 pounds of lamb produced per ewe. About one-half the lambs in the band were crossbred Hampshire-Rambouillet and the other half were pure Rambouillet After being weighed from the mountains, 402 of the heaviest lambs were shipped to Chicago. Of these 331 were crossbred and 71 were Rambouillet. All of the Rambouillets were sold as feeders and 230 of the crossbred lambs were sold as killers. This demonstrates the fact that if milk-fat lambs are to be produced from range ewes, it is necessary to use rams of mutton breeding. Two hundred and thirty of the more desirable type Rambouillet ewe lambs were retained for breeding stock and the rest were used in lamb feeding trials at Huntley and at Bozeman.

Dried beet pulp and alfalfa for wintering breeding ewes.—An experiment was conducted to determine the value of substituting dried beet pulp for part of the alfalfa in the ration. One lot was fed 3.06 pounds of alfalfa hay and another lot 2.01 pounds of alfalfa and 0.5 of a pound of dried beet pulp for a period of 84 days. The ewes in the alfalfa lot made an average gain of 8.9 pounds while those fed hay and pulp made an average gain of 8.4 pounds. One pound of dried pulp replced almost two pounds of alfalfa. When sufficient alfalfa hay is available and does not cost more than one-half as much per ton as dried beet pulp it is more economical than to substitute pulp for part of the ration. This experiment is important in that it shows that when the hay supply is limited, it can be stretched by substituting dried beet pulp.

A limited roughage ration for breeding ewes.—In order to study the effect of a limited hay ration compared with a full ration of hay on lamb and wool production, one lot of ewes was fed all the hay they would consume for the 84 days. They ate an average of 4.42 pounds of alfalfa per head per day and gained an averge of 21.8 pounds for the period, while the limited-fed ewes which were fed 3.09 pounds of hay per head per day gained 8.9 pounds. The lambs from the full-fed ewes were 1.9 pounds heavier and the fleeces were 0.66 of a pound

heavier than those from the limited-fed ewes. The fleeces, however, contained more grease so that there was actually little difference in the amount of clean wool produced. The increased lamb and wool production resulting from heavy feeding of hay did not pay for the extra feed required.

Limited and full feeding of ewe lambs.—The ewe lambs kept for replacement were divided into two lots for wintering. One lot, fed 2.03 pounds of alfalfa per head per day, made an average gain of 2.03 pounds per head in 113 days. The other lot, fed 2.44 pounds of alfalfa and 0.33 of a pound of dried beet pulp per head per day, made an average gain of 14.35 pounds. The fleeces from the full-fed lambs were 0.79 of a pound heavier but here again the increased weight was largely due to more grease.

The summer gains for the limited-fed lambs were much greater than for the full-fed lambs. Adding the winter and summer gains for each lot shows that limiting the winter ration for ewe lambs does not materially affect their weight as yearlings. There was a difference of only 1.71 pounds in their fall weights. The results of this test show that there is no economy in liberal winter feeding if good summer range is available.

SERVICES TO THE LIVESTOCK INDUSTRY OF THE STATE

The Veterinary Research Laboratory

The largest agricultural industry in Montana is livestock production. This phase of the agriculture of the state has always been fundamental but it will be even more so in the future, as livestock will be a source of income in practically all phases of our agricultural production. Moreover, the range country will continue to occupy over 80 per cent of the land area of the state and will in the future, as in the past, produce the greater proportion of the cattle and sheep of the state.

It is with this in mind that the Veterinary Research Laboratory is giving the larger proportion of its energies to the study of diseases found among range livestock and to devising methods by which these animals may be treated conveniently and effectively on the range. Some of these problems and the methods of meeting them are presented herewith:

SIMPLIFYING THE PROBLEM OF DISEASE CONTROL ON THE RANGE

Infectious abortion.—A typical instance of the application of disease control measures to livestock on the range has been worked out in connection with the study of Bang's disease (infectious abortion) in cattle under range conditions. One phase of this study, which has recently been completed, is the development of a whole-blood agglutination test which can be used in the field. In applying the standard laboratory test, the blood is drawn from the cow, each animal is ear tagged or marked in some way for individual identification, and the blood is shipped to the laboratory for test. When the report comes back from the laboratory, the herd is worked again and the reactors identified and cut out. The individual identification and the second handling of the cattle make testing of large herds under range conditions very difficult and expensive. The use of the field test which has been developed eliminates the necessity of individual identification and of a second handling of the cattle. The test is completed while the cattle are still in the bleeding chute, and the reactors can be marked and cut out immediately. By taking advantage of the possibility of testing by this method, many range herds can be given an annual test at shipping time in the fall, when all reactors may be culled out and disposed of immediately.

Foot rot of sheep.—Range sheep sometimes become badly affected with foot rot. In bands of several thousand it is not an easy problem to treat such sheep effectively and do all the work in a reasonable time. The laboratory has developed a method of control which has been operated successfully even when it was necessary to handle as many as 40,000 sheep for one outfit.

Arthritis in lambs. Arthritis frequently affects lambs that are dropped in sheds. The joint infection, which produces lameness and affects the growth of the lamb, is caused by infection with a specific micro-organism, either of the navel cord at birth or of the wounds from docking or castrating. Cleanliness, navel disinfection, and proper docking prevent this trouble. Iodine as a disinfectant and docking with a hot iron have been the methods used. Plans have been worked out for quick and effective treatment in handling largs numbers tof lambs.

Acute diarrhea has caused very serious losses of lambs in many flocks in the state. It is particularly serious when the flock is lambed in sheds, unless these are kept clean and thoroughly disinfected. All

the facts in regard to the cause of this trouble and its prevention and elimination are not yet ascertained. Preventive measures that have proved helpful are clean sheds, removing tags from around the udders of the ewes, holding the drop band on clean, well-drained ground, and protecting the lambs from chilling and moisture.

Other types of diseases which trouble sheep and cattle on the range are being studied. Some are of such a nature that very little progress has been made in discovering their cause or how to combat them, though new facts are continually being added to our knowledge. On other problems more progress is being made but time and persistency, with close and accurate study, are necessary in working out control measures and adapting them to use in treating animals on the range.

THE GRAIN INSPECTION LABORATORY

Benefits the Montana Grain Grower

The Montana Grain Inspection Laboratory was established for the two-fold purpose of service and of research. Service takes care of the immediate needs of testing seeds for planting, and grading and testing the yearly crops, while research has to do with fundamental principles, with aspects of seed viability, and with the quality and adaptability of the various kinds of grain. Both of these are of primary importance to Montana's agriculture in its present stage and also to the new forms into which it may develop in the future.

As crops become more specialized and new varieties are developed, greater emphasis is placed upon the seed, and seeds which are offered for sale must fulfill certain requirements if they are to meet the needs of the buyer. As grains become more highly developed, and this is particularly true of wheat in Montana, their adaptability for certain purposes must be studied. Quality, both in seeds for planting and in wheat for making flour which is used for special purposes, has been of much importance in the past, and it will be still more important in agriculture's new era when there will be need for wheat adapted to many purposes.

During the twenty-one years of the laboratory service 102,007 samples of seed have been received for testing as to purity and germination; 20,266 lots of grain have been graded; 27,926 lots of wheat have been tested for protein; and 5,985 milling and baking tests have been made. This work has improved the quality of the cereals grown

in the state by encouraging the production of the best. Farmers and dealers rely more and more on the laboratory as a source of information on seeds of all kinds and on problems relating to marketing grain.

The seed testing and inspection service is doing much toward providing a better quality of seed for Montana farmers, and it also guards them against inferior seeds shipped into this state. The seed testing service offered by the laboratory has fitted in well with the crop standardization program carried on by the Montana Seed Growers Association. The laboratory also tests Montana seeds which are shipped to other states. This is an important factor in maintaining Montana's reputation for superior seed.

The following examples show what this service means to Montana farmers:

1. One lot of alfalfa seed, consisting of 1900 pounds, which was offered for sale bore no label as required by the state law. A careful analysis of this seed showed it to contain 35.7 per cent sweet clover.

2. A supply of timothy seed bore a label claiming 95 per cent germination, while a laboratory test of the sample showed but 62 per cent. This was probably old seed.

3. A quantity of oats was advertised as seed in a local paper. An inspection showed no label. The sample taken by the inspector tested 98 per cent purity or, on this basis, a good lot of seed; but the laboratory test showed only 30 per cent germination. The apearance of seeds is often deceiving.

4. A lot of white clover seed offered for sale in Montana, in the spring of 1934, was found to bear the label of a wholesaler from another state. This label showed a purity of 98 per cent with 0.65 per cent weed seeds. The laboratory analysis showed it to have a purity of 94.2 per cent, with 4.9 per cent weed seeds. Most of these seeds were yellow trefoil, a very bad weed in lawns and meadows. Buyers cannot always rely upon wholesaler's labels and should have check tests made by the seed-testing laboratory.

Grain grading and marketing.—The employees of the grain laboratory are licensed inspectors for the grading of grain according to federal standards. This service has been extensively used by Montana farmers and has done much to improve conditions under which

grain is marketed. It has also made possible the settling of many disputes between buyer and seller. A laboratory has demonstrated the value of the smut dockage test for wheat as compared with an estimated discount formerly used. This test places smutty wheat on a much fairer basis in the market.

Value of protein tests in marketing wheat.—The practice now generally followed of selling wheat according to its protein content has probably benefited Montana wheat growers more than any other marketing practice which has been advocated by the Montana Grain Inspection Laboratory. The difficulty of estimating the protein content of wheat with any degree of accuracy led to the development by the Grain Laboratory of a simple and dependable chemical test. This has been a very important factor in bringing to the wheat growers of the state the premiums now paid for the high percentage of protein. In addition to this service the laboratory has done much to demonstrated the importance of the protein content of wheat in relation to the baking properties of the flour.

THE HORTICULTURAL BRANCH STATION SERVES THE WESTERN PART OF THE STATE

This branch station, located near Corvallis in the Bitter Root Valley, makes a careful study of the fruit problems of this part of the state, where in many areas commercial fruit growing is possible. Studies are also in progress with many vegetables adapted to the soil and weather conditions of this area. If these crops increase, the marketing problem will have to be given serious consideration. The only important commercial tree fruits are the apple and the sour and sweet cherries. Of the small fruits, strawberries are of first importance but raspberries do well. The major problems are fertilization and cultivation.

Fertilizers and cover crops for apple orchards.—Orchards grown with cover crops or under clean cultivation make quite different responses in yield, size of fruit, and color of fruit. Moreover, the fertilizer programs necessary under these two sets of conditions vary materially. A comparison of two orchards which for some years have been included in fertilizer tests, one of which has been clean cultivated and the other seeded with an alfalfa crop disked every spring, shows that the orchard seeded to alfalfa is holding up in vegetative growth much better than the clean-cultivated orchard and the average

size of fruit is larger. With trees of comparable size the yields also exceed those on the clean cultivated orchard. The color of the fruit in the cover-cropped orchard, however, is lower than in the clean-cultivated orchard.

Phosphorus applied on the surface and disked into the soil, materially improves the color of the fruit from the orchard with the alfalfa. The amount of nitrogen fertilizer needed when alfalfa is grown in the orchard is very much less than when under clean cultivation. Under the latter condition parts of the ground are beginning to develop symptoms of "drought spot." The study of these two orchards leads to the conclusion that cover crops are apparently keeping the trees in better physical condition and the trees require less commercial nitrogen and produce larger yields and bigger fruit. Apparently only phosphorus is needed to hold up the quality of the fruit.

Fertilizers for sweet cherries.—The sweet cherry responds to commercial fertilizer in much the same way as does the apple. On the older trees applications of nitrogen have increased the size of the fruit. While only nitrogen has been used, however, there are indications that the fruit is somewhat softer than where other fertilizers and cultural methods have been followed. When nitrogen alone was applied the maturity of the trees was delayed and they frequently remained green and held their leaves extremly late in the fall.

The benefits from phosphorus have been pronounced in three directions. First, the trees have matured their wood and prepared for the winter in good shape, thereby avoiding winter injury, particularly of the young trees. Second, the fruit is firmer and has better handling qualities than where only nitrogen was used. Third, phosphorus has produced better colored fruit and a more uniform development of the color on all fruit.

Potash has distinctly influenced cherry trees and their fruit in two ways. First, it has appeared to delay maturity of the wood in the fall, the trees remaining in a soft growing condition and subject to injury in case of severe cold weather early in the season. Second, on bearing trees potash has delayed development of color and resulted in unevenness of fruit color throughout the tree.

Fertilizer tests indicate that the use of phosphorus on young trees aids the maturity of the wood. On bearing trees phosphorus is also desirable because of its influence on the maturity, color, and

firmness of the fruit. Nitrogen should be used in sufficient quantities to keep up normal tree growth, increase the yeilds, and maintain the size of the fruit.

Value of cover crops in cherry orchards.—Observations made in a number of orchards, of both sweet and sour cherries, seem to indicate the desirability of cover crops. The young cherry orchards in the Flathead area tend to make too much growth and to continue growth too late in the season. As a result pruning problems are more difficult and the maturity of the wood has been distinctly delayed. Cover crops have helped to hold down extreme growth, thus contributing toward earlier maturity. It has also been noted that the cherry orchards maintained in alfalfa have lost fewer trees and are in better condition than those which have been clean cultivated. Cover crops seem to have lengthened the life of the cherry orchard.

Strawberry yellows.—A major problem with strawberries in western Montana is the occurrence of yellow-leaved plants, which reduce stand and yield as well as the sales value of the plants. In tests at the station, plants were obtained from lots selected from various sources by commercial growers, some being affected and others free from yellows. Both the diseased and the healthy selections were divided into two lots. When planted, one half of each lot was treated with phosphorus and the other half left without such treatment. The plants free from the yellows gave much the larger yield and the application of phosphorus further increased the yield. No yellow plants developed from those treated with phosphorus though some yellow plants appeared among the apparently healthy plants not so treated. This indicates a possibility of overcoming this trouble by careful selection of healthy plants and the use of phosphorus.

Varieties of strawberries.—Considering its yield, quality, handling and shipping characteristics, the Bitter Root Progressive strawberry, an everbearing variety, is one of the best berries grown in the western part of the state. Its one weakness is susceptibility to yellows. While many other varieties have been tested at the station none equals it in all around value. If further tests demonstrate that the method of selection and treatment outlined above will overcome the yellows, the Progressive is yet the best strawberry for this area of the state.

Of the one-crop strawberries, the Gandy, an old variety, shows distinct promise for use in Montana. The flower stalks are semi-

erect but well protected by foliage. It is among the later varieties in blooming and fruiting. Many other one-crop varieties have been tested, among them Corvallis, Blakemore, Redheart, Washington, Narcissa, Culver, Cato, Camden, Clermont, and Fairfax, but none has proved entirely satisfactory at this station. A characteristic which rules out many varieties is the erect flower stalk which is particularly objectionable in Montana because of liability to much greater damage from frost.

THE JUDITH BASIN BRANCH STATION POINTS OUT THE WAY FOR CENTRAL MONTANA

This station, located near Moccasin, is given wholly to dry farming studies with cereal and forage crops and with livestock. About 600 acres are controlled by the station and no more stock is kept than can be maintained on this area both winter and summer.

Agriculture in the Judith Basin passed through its first transition period in the homestead days of 1905 to 1915 when the range livestock business gave way to wheat farming. After twenty-five to thirty years devoted almost exclusively to wheat production, agriculture in the Judith Basin is again faced with a new set of problems. A succession of dry years, with the attendant evils of soil blowing, depleted soil fertility, weeds, and insect pests, has caused the abandonment of what was once considered good wheat land. On the remaining areas of better farm land greater yields of wheat must be secured in the next ten years than in the past ten, or they too will fall into the group of submarginal lands. Two of the problems facing agriculture in the Judith Basin then are, first, what disposition can be made of the lands which are no longer suitable for wheat production, and second, can more efficient methods be adopted on the better class of lands?

Regrassing dry land areas.—Regrassing is the answer to the problem of the submarginal areas as well as some of the better class of lands on which the operators would like to include some livestock enterprise with their wheat growing, but are now prevented from so doing by the lack of grass. There are two methods of regrassing: first, allowing nature to take its course, which on Montana dry lands requires twenty-five to forty years; second, by artificial reseeding with crested wheat grass, brome grass, or other species. The Judith Basin Branch Station has spent twenty years in testing different

species of grass and studying how reseeding of cultivated lands may be accomplished. It has been proved on a large scale that this reseeding of cultivated lands in the Judith Basin can be done and the lands returned to their original usefulness as grazing areas. Crested wheat grass is the most valuable grass for reseeding purposes and methods are being developed by which this can be accomplished with considerable assurance of success. The Judith Basin Branch Station has not only tested methods and means of securing stands of crested wheat grass but has made studies of its value for grazing livestock. Eight years' experiments with grazing cattle on crested wheat grass and brome grass show them to be superior to native grass in carrying capacity and to have a high feeding value. During the past few drought years the experiments indicate that even the better class of farm lands in the Judith Basin may be as well adapted to the production of beef or mutton as to wheat. Grasses may also be used to control soil blowing and will restore organic matter and plant food to the soil.

Another problem faced by wheat growers in the Judith Basin is the loss of stands by winterkilling. After each season of heavy loss of stands of winter wheat, attempts are made to grow spring wheat with indifferent results. Experience during the past ten years has convinced nearly everyone that winter wheat is a much more profitable crop to grow if it survives the winters. Thus the need for winter-hardy varieties of wheat is acute. Appreciating this need the station some ten years ago, in cooperation with the Division of Cereal Crops and Disease, of the United States Department of Agriculture, started a comprehensive plant breeding program to produce a variety of winter wheat which was winter hardy and adapted to Montana conditions. Several crosses of different wheats have been made in an effort to produce varieties having superior winter hardiness together with the other desired characteristics. Among their several hundred progeny one has been developed to the point where it has been given to a number of selected growers for final testing before a decision is made as to whether its superiority is sufficient to warrant widespread distribution. This variety has been given the name of Yogo. In additon to its desirable characteristic of superior winter hardiness, it shows considerable resistance to the Montana forms of stinking smut and yields well. As previously mentioned, however, further testing is necessary before its adaptability to other parts of

Montana will be known. In addition to this variety, several selections of winter wheat which show much promise, but are as yet unnamed, are being tested at the Judith Basin Branch Station. Even though the variety Yogo may not fully meet the final tests, it shows that progress toward solution of the vexing problem is being made.

THE NORTHERN MONTANA BRANCH STATION WORKS ON THE CROPS AND LIVESTOCK PROBLEMS OF THE NORTHERN REGION

This station is located near Havre, in the north-central part of the state. It therefore serves especially all the northern part of the state east of the Rocky Mountains. Its work is confined to field studies with grain and forage crops on dry land, and experiments in breeding and feeding beef cattle. It has been in operation since 1916, when the homestead era was at its height. Crop conditions were excellent in 1915 and 1916, and the war in Europe promised increasing prices. It was in this atmosphere of keen demand for information on crop production that experimental work at the station was started. With limited funds available, the experiments dealt only with agronomic questions, and this work has been carried along to the present with very little interruption. The 18 years of investigational work have given many facts of much value to the agriculture of this northern dry-land area. A few of these are discussed below.

Benefits of fallow in growing small grains on dry land.—Crop rotations and tillage tests at this station include nearly every method and rotation that might have promise for this section. These studies show that alternate fallow and crop has had an advantage over other methods for the production of small grains. During periods of extreme drought, when there were more than two consecutive dry years, yields of small grains on fallow were often not much larger than by other methods—all were very poor. During the more favorable years, however, summer fallow fully justifies itself. Within the past one or two decades there has been a decided improvement in cultivating machinery, making possible much reduction in the cost of taking care of fallow as the number of operations has been decreased. These implements also leave the soil in much better condition for control of blowing.

Methods of fallowing.—A comparison of the results during 18 years of tests on time of plowing, whether in the fall, in May, or in early July, shows that yields from fall plowing left rough during the winter, and also from May plowing, were about equal, but July plowing gave normally from 5 to 7 bushels less per acre. Fall plowing for fallow has a little disadvantage over May plowing because the fallow goes through two winters in a bare condition, and the surface soil often becomes so fine that soil drifting may become serious.

Cultivation of stubble before plowing did not increase the yields on fall-plowed fallow or May-plowed fallow. However, if land was cultivated in the spring it was usually better to continue cultivation through the summer as plowless fallow rather than to attempt to plow later on. July plowing, even when cultivated earlier in the spring, has yielded 2 or 3 bushels of wheat less than properly handled plowless fallow.

Continuous plowless fallow has resulted in an average decrease of 2.8 bushels of wheat per acre, as compared with May-plowed fallow. The stubble and trash remaining on the surface of plowless fallow help to prevent soil blowing, but might have the disadvantage of affording protection for insect pests.

Subsoiling to a depth of 18 inches has not increased yields enough to pay for the cost. Plowing for fallow from 6 to 8 inches deep has proved most satisfactory, for the trash is then well turned under and in many soils more clay is brought to the surface, forming clods which tend to control soil blowing.

Extremely deep cultivation of plowed fallow during the summer for the control of weeds has not been as satisfactory as medium to shallow cultivation. Soils usually dry out as deep as they are cultivated, and for that reason fallowed land should be worked only deep enough to eradicate weeds.

Allowing weeds to grow unhindered during the fallow period, to be burned the following spring just before seeding, has not proved satisfactory. This method has often resulted in weedy stands and the average yield has been less than on ordinary summer fallow.

The control of soil blowing is a problem that is becoming more difficult where alternate fallowing and cropping is used. Strip farming, with strips about 200 feet wide, has aided materially in solving this problem. Other practices that help are plowing deep

enough to turn up some clay, cultivating when the soil is wet, and managing the cultivation so as to maintain a cloddy mulch.

Continuous corn.—The continuous growing of corn from year to year is a practice that has given very good yields. The yields of stover and shelled corn have been increased considerably above those of corn grown after small grains. Corn is grown mostly for farm feed or for hogging down in the field. Where hogging down is practiced, nearness to water is an advantage, and often additional fencing is necessary, so the corn field should be as permanent as possible. Corn grown continuously is cheaper to produce because less cultivation is usually required to control weeds. Unless the soil tends to blow, plowing is not necessary oftener than every two or three years. Station results show this to be a very good method, especially as long as the field is free from disease.

VARIETY TESTING AND PLANT BREEDING

Climactic conditions in the northern and eastern part of Montana are more extreme than in the mountain valleys and western part. Drought conditions are more general, and at harvest time humidity is lower and temperatures higher. As a result the ripening of grains from July 15 to August 15 is usually rapid and somewhat forced. This results in a difference in varietal response of crops between the plains and the mountain sections, and these same differences have a bearing on the selections and the plant breeding work, the object of which is to improve varieties for this section of the state.

Variety testing has been under way since 1916 and has included wheat, oats, barley, rye, flax, alfalfa, sweet clover, grasses, millets, sorgo, corn, and some miscellaneous crops such as beans, potatoes, sunflowers, and safflower. New varieties and strains are being continually developed both by public and by private agencies. One of the important features of the station work is the determination of the value of these new varieties.

Because their adaptability has been proved at this station, seeds of several varieties of grain have been increased and distributed with very satisfactory results. One of the first was Horn barley. White Smyrna was formerly the leading variety at this station, but it has been replaced by Horn, which has a high yield of excellent quality, with enough height of straw to be harvested easily. Horn barley is now grown to the exclusion of other varieties in several areas in Montana. Its superior quality brings a higher price on the market.

Prolific spring rye has been grown at this station for several years in comparison with other spring grains and has proved to be one of the best grains for hay. Seed has been distributed and it is being grown quite extensively for both hay and grain over this section of the state. Its general use is almost entirely the result of station tests.

Idamine oats, developed under irrigation in southern Idaho, have at this station yielded relatively well under dry-land conditions. This is a white oat of good quality, and will probably replace Victory on dry land over the greater part of this section of Montana. It also yields well under irrigation in Montana.

Ladak alfalfa, imported from India by the United States Department of Agriculture, has done well, and seed has been grown for distribution. The yields are good and at this station it is more hardy than Grimm. It is also one of the most resistant to alfalfa wilt.

Crested wheat grass, because of its hardiness and adaptability to this area, is quite outstanding. Stands of this grass have held up for fifteen years with very little reduction in yield. It has consistently outyielded brome grass and slender wheat grass. Crested wheat grass seeds heavily, and under favorable conditions new stands are obtained without difficulty. It has proved a very good pasture grass and produced hay at least equal in quality to brome grass or slender wheat grass. Because of its ability to yield more than native grass, its hardiness and longevity, crested wheat grass should fill a very large place in regrassing land that was ployed for grain. It covers the ground in a few years under the average rainfall of northern Montana.

SHELTER BELTS, ORNAMENTALS, AND SHRUBS

Trees and shrubs are especially valuable to farm homes in the plains area of Montana, but to thrive they need somewhat artificial conditions. Only the more hardy varieties will stand the cold and drought, and even these should have the advantage of cultural treatment that will aid in their competition with other vegetation.

The first shelter belt plantings at this station were made in 1917 and included the following deciduous varieties: American elm, Chinese elm, box elder, laurel-leaved and golden willow, green ash, native red birch, and northwest poplar. The American elm and the green ash are the outstanding trees in this test. Planted as they

were, rather close together, they have not reached a height of more than 15 to 20 feet, but without pruning this has been enough for a satisfactory windbreak and shelter belt. The box elder winter killed rather severely and has been removed except in favorable locations. The northwest poplar, willows, and birch were all killed either by severe conditions or by disease.

The first planting of conifers was started in 1919, but because of severe spring conditions a satisfactory stand was not obtained until 1922. Three varieties were included in this test—western yellow pine, jack pine, and Black Hills spruce. The western yellow pine has proved outstanding. It is difficult to transplant, however, and as an individual tree is not very attractive. On well-drained land it has withstood severe drought and extreme winters and has made a satisfactory shelter belt, fitting well into clumps. It survived the drought of 1929-1931, which killed a large part of the jack pine and Black Hills spruce.

A second successful planting of conifers was made in 1927, using jack, Scotch, and Norway pines, and the Colorado and Black Hills spruces. The Scotch pine and the Colorado blue spruce are the best of these five varieties. Norway pine killed entirely and the jack pine was severely damaged in 1930 and 1931. The Black Hills spruce showed some damage in 1934. A caragana hedge in connection with this planting has been very hardy and has served well as a protection for evergreens.

Ornamental plantings have been made during the last six years. These have had the advantage of some irrigation. Some of the hardy shrubs in this test are spirea Van Houttei, common Persian and Villosa lilacs, Tartarian honeysuckle, staghorn sumac, caragana, native dogwood, mock organge, purple-leaved sand cherry, and golden elder.

Iris has been quite hardy and fits in very well for ornamental purposes. Thirty-eight of the forty-four varieties planted have withstood three years of rather severe conditions. With a fairly wide variation in color and with a range of at least two months in time of blooming, the different varieties of iris show promise for ornamental planting around farm homes.

A NEW OUTLOOK FOR BEEF CATTLE IN MONTANA

A small herd of high grade Hereford heifers was purchased in 1917 as a foundation for cattle experiments at the Northern Montana Branch Station. Tests beginning in 1921 have dealt largely with the use of locally grown feeds for winter maintenance of both mature cows and growing heifers, and for the finishing of young beef. The following roughages have been used in maintaining a breeding herd of beef cattle: oat hay, sweet clover, spring rye, winter rye, bluejoint, alfalfa, and corn fodder. Oat hay has proved a rather outstanding feed, while spring and winter rye, bluejoint, and sweet clover have been about equal to alfalfa in feeding value. From 17 to 19 pounds per day of any of these feeds will produce about 50 pounds of gain during the 100 days preceding calving; 15 to 16 pounds of oat hay will produce the same gain. The feeding value of corn fodder is quite variable from year to year when grown locally, as the growing conditions affect the moisture content as well as the percentage of grain in the fodder. At least 18 to 20 pounds of corn fodder daily are necessary to produce gains equivalent to those made by alfalfa.

There has been no advantage in feeding breeding cows for heavy gains during the winter, for the calves produced have been no larger than those from cows that have come through the winter in just moderately low condition. The cows that make heavy gains in the winter usually gain much less on grass in the summer. The cows receiving limited feed in the winter are more economical as their gains are made mostly on grass. Cows that were wintered on rations containing a small amount of protein, such as corn fodder and bluejoint hay, produced as good calves as cows that were wintered on high protein rations, such as alfalfa and sweet clover. There has been no significant difference in the birth weights of these calves, or in their weights at weaning time.

Locally grown wheat and barley have proved satisfactory in finishing yearling steers. On both the St. Paul and the Spokane markets these steers have sold at top prices. The "Montana plan," by which steers are fed limited grain the first winter, with grain and grass the next summer, followed by about 75 days in the dry lot in the fall, has produced an economical finish. These steers are on the market at about 18 months of age and at a weight that the recent markets demand. Full feeding of calves, beginning at weaning time

and finishing at about 13 months, has also been successful with local feeds. Both these methods are being used in many places in the state as a result of experimental work at this station.

SOME RESULTS IN WINTERING BREEDING COWS

A ration that will be economical and yet bring the cows through the winter in good condition and capable of producing strong, healthy calves is one of the factors in wintering breeding beef cows. Seventy cows at the station were divided into 5 uniform lots with 14 cows in each. They were fed 17 pounds of roughage per head daily for 105 days. The kinds of roughage and the results from the feeding are given in table 5. Only 60 of the cows dropped calves and all were fed and handled alike from March 22 to October 23, a period of 217 days.

TABLE 5.—RESULTS OF FEEDING DIFFERENT ROUGHAGES TO BREEDING COWS

Rations fed	Winter gain of cows	Weight of calves		Loss in weight of cows[a]
		At birth	At weaning	
	lbs.	lbs.	lbs.	lbs.
Oat hay	87.0	78.2	418.8	181.0
Spring rye	49.7	76.3	393.6	160.0
Alfalfa hay	26.7	68.5	395.4	135.0
Winter rye	3.7	75.1	389.1	89.0
Alfalfa hay 10.8 lbs. and grain 2 lbs. per day	10.8[b]	76.6	367.1	83.5

[a]This loss in weight is from March 22nd before birth of calves until they were weaned.

[b]Loss.

Oat hay heads the list as a winter feed, while spring rye is a close second. From this season's experience, 2 pounds of grain added to 11 pounds of alfalfa did not prove so good a ration as 17 pounds of alfalfa. There is some correlation between the winter gains of the cows and the birth weights and weaning weights of the calves. It also appears that the cows which gained most in the winter lost most through the pasture season.

Full and light winter rations in developing heifers.—For some years tests have been conducted to compare results from the use of a full ration and a half ration of hay during the winter in feeding heifers ranging in age from calves to two-year-olds. Table 6 gives the results of these tests.

TABLE 6.—COMPARISON OF FEEDING FULL HAY RATION AND HALF HAY RATION

	Hay fed per head per day	Gain at end of feeding period	Gain at end of grazing period	Gain 365 days
	lbs.	lbs.	lbs.	lbs.
Heifer calves (155 days)				
Alfalfa, full ration	12.82	185.8	135.0	366.8
Alfalfa, half ration	6.41	21.3	214.2	297.1
Yearling heifers (139 days)				
Alfalfa, full ration	19.44	117.4	84.0	201.4
Alfalfa, half ration	11.70	8.1	190.0	198.1
Two-year-old heifers (105 days)				
Hay, full ration	22.65	115.5	——	——
Hay, half ration	13.01	25.3	——	——

The interesting fact shown in this table is that while heifers of all ages made good gains on the full ration during the winter and small gains or a loss on the half ration, yet during the summer pasture season the heifers which received the light winter ration made very much greater gains than those which received a full winter ration. The yearling heifers which had received the light ration during the winter gained nearly twice as much on pasture as did those fed more heavily in the winter. If this result is borne out in future tests, it would seem that the economical practice would be to carry the heifers through the winter on a ration that will merely maintain their weight.

Effect of type of sire on birth and mature weight of heifers.—For some years Hereford bulls of a large type and a small type have been used with beef cows at this station. Since the test started there are records on 208 heifers from the large type bulls and on 248 heifers from the small type. On the average the calves from the large type bulls weighed at birth 6.5 pounds more, at weaning time 21.5 pounds, as yearlings 30.3 pounds, and as two-year-olds 26.9 pounds more than calves from the small type bulls. As three-year-olds, however, the heifers from the small type bulls averaged 5.8 pounds more than those from the large type. In other words, the heifers from the small type bulls start at lower weights but at maturity have grown out to fully equal the weights of the heifers from the larger bulls.

THE HUNTLEY BRANCH STATION

THE PROBLEMS OF MONTANA'S LOWER IRRIGATED VALLEYS

This station, located near Huntley, is a field station of the Bureau of Plant Industry, United States Department of Agriculture. It is owned and operated by that department, but for a small state appropriation the Montana Experiment Station gets reports on the investigations. Experiments are being carried on both under irrigated and dry-land conditions. This area has a longer season and a warmer climate than the Gallatin Valley, and so supplements the studies at Bozeman. Studies are also in progress with dairy cows.

Irrigated crop studies.—The crop rotation experiments which have been in progress at this station for 23 years show wide differences in yield because of the different crop sequences. The yields from the short rotations not manured and from continuously cropped plots have for several years been so low as to be unprofitable. In the rotations that contain alfalfa and in which manure is applied, high yields are being maintained and in some cases increased. A rotation with 3 years of alfalfa which was effective for several years in maintaining yields of other crops such as beets, potatoes, and grain, at a fairly good level, has in recent years shown a rapid decline in the yields in these crops, particularly of beets. It is now evident that other treatments, in addition to the alfalfa, must be applied to produce satisfactory yields.

An example of the effect and value of manure is found in the average yield of beets in some of these rotations during the past 5 years. For this period, the average yield of beets, in a 2-year rotation of oats and beets, was 3.88 tons per acre; in a 3-year rotation of potatoes, oats, and beets, the 5-year average yield was 7.97 tons; while in a rotation of potatoes, oats, beets, and 3 years of alfalfa, with manure applied to the beet crop, the yield of beets was 17.42 tons per acre. Corresponding differences have occurred in the yields of other crops in these rotations.

In another cropping experiment under way during the past 9 years, an effort has been made to determine the maximum yielding capacity of the soils of the Huntley station. In this experiment manure is applied regularly to all cultivated crops and to alfalfa while commercial fertilizers are applied to other crops at different times. The average acre yields over the 9-year period in this rotation were as follows: alfalfa, 6.87 tons; sugar beets, 22.26 tons;

potatoes, 480.9 bushels; corn, 72.5 bushels; oats, 101.4 bushels; wheat, 56.7 bushels; and beans, 48.5 bushels.

The field in which this rotation was started was broken from native sod in 1917, cropped to small grain for 2 years, and for the following years was in alfalfa. This rotation was started in 1926. Farmyard manure was applied each year to the alfalfa, potatoes, sugar beets, and beans at the rate of 16 tons per acre. Superphosphate was applied to the oats, sugar beets, and wheat.

INVESTIGATIONS IN DRY-LAND AGRICULTURE

These investigations have been carried on without interruption since 1912. During the 22 years of the experimentation a mass of data has been obtained on crop behavior through many types of growing seasons, and we are now getting the cumulative results over this period of years. The recent years of extreme drought and poor prices for agricultural products have but emphasized the value of these experiments in the efficient use of soils and of tillage methods in combination with low-cost production plans.

Yields have been below the average during recent seasons, but the returns from the well-balanced, diversified rotations have generally been superior to those from other cropping systems. For instance, the average acre yield of a rotation comprising a cash-grain crop on fallow, followed by corn, which in turn is followed by a feed-grain crop on disked corn land, has usually been greater than the average acre return from a small grain on fallow or from a rotation of small grains without corn. Should a shorter rotation be desired, the investigations have shown that the fallow rather than the corn should be omitted if the greater yields to the acre for the rotation as a whole are to be maintained.

Another conclusion from these studies is that the expense of producing the various crops has been materially reduced by the newer types of farm machinery used in the preparation of the land, and in cultivating and harvesting the crops. Moreover, the yields from the cheaper tillage methods have usually equalled or exceeded those obtained from the more costly treatments. Timeliness in performing cultural operations is an important factor in yields. The summer fallow should be plowed early, thorough tillage given before weeds go to seed, and prompt cultivation of the corn before the weeds rob the soil of moisture.

The years of drought have shown the wisdom of having a reserve feed supply for livestock on the dry farm. Early-maturing varieties of corn and sorgo have been found quite tolerant of drought; sorgo, especially, has returned good yields of fine-quality forage nearly every season. These crops may be stored dry or in a silo. Sudan grass, and Ladak and Grimm alfalfa have usually produced crops of good hay, which, when properly cured, may be stored in stacks or barns and held in reserve to balance the good and poor years.

DAIRY WORK AT THE HUNTLEY FIELD STATION

Dairying in the irrigated valleys of Montana forms one of the important agricultural industries. Climatic conditions make possible roughages of superior quality, especially alfalfa hay, while irrigated pastures grow luxuriantly and provide the greater portion of the feed during the summer months.

Data secured at this station show that roughages of high qaulity fed to dairy cows produce milk and butterfat more economically than when this ration is supplemented by grain. A problem growing out of this is to determine methods whereby the quality of the roughage crops may be improved.

Studies at this station indicate that the quality of the roughage is improved by harvesting the crop at a less mature stage than heretofore has been done. This results in a higher percentage of protein and a lower percentage of crude fibre. In one experiment the cutting of pasture grasses as a soilage crop indicated that the more often the crop is harvested the greater the total yield of digestible nturients obtained. The total amount of protein harvested on a mature basis amounted to 368.2 pounds per acre, while when cut in a more immature state the yield was 740.2 pounds of protein per acre. In another experiment pasture grasses ensiled or cut for hay made a splendid roughage feed for dairy cows. These tests show that surplus pasturage can be harvested during the flush season and used as supplemental feed during that part of the season when growth is less abundant.

Reed canary grass has been introduced as a pasture crop and during the past two exceedingly dry seasons has produced practically as great an amount of nutrients for dairy cows as has our regular Huntley mixture.

The pen or open-shed type of barn for dairy cattle, in use during the past 5 years, has been found a very desirable and most economical

shelter. Records of production with cows in this type of shelter compare quite favorably with those obtained previous to its use. An advantage of this type of structure is that manure may accumulate in the shed during that part of the year in which it is impracticable to apply this fertilizer to the growing crop.

A major experiment carried on at this station is the securing of a superior germ plasm in dairy cattle. A strain of dairy cattle is being bred toward an inheritance of desired characteristics that will be so fixed that they can be depended upon to transmit to the offspring high levels of milk and butterfat production. This is being accomplished by the use of proved sires. Some of the station herd sires are loaned to neighboring dairymen and records are secured of their offspring. Up to date, 57 sires have been tested in these herds. Their daughters, numbering 580 head, have produced an average of 1,495.8 pounds of milk and 57.41 pounds of butterfat annually, more than did their dams.

STUDYING RANGE LIVESTOCK

United States Range Livestock Station

This station, located on the old Fort Keogh Military Reservation near Miles City, is owned and operated by the Bureau of Animal Industry, United States Department of Agriculture. Only a small appropriation for the suport of this work has been made by the State of Montana, but the Montana Station has free access to the results of its work. Experiments have been carried on with horses, cattle, sheep, hogs, and poultry. The chief task this station has set itself is the gathering of exact information on handling and feeding livestock on the range, so that the most profitable practices can be promoted. The results at the station apply especially to the eastern plains area of the state.

Beef cattle investigation.—In the beef investigation the principal problem has been the development of economical rations for wintering cattle on the range and in the feed lot.

Mature breeding cows tend to maintain their weight from year to year until they begin failing physically. All classes of young and growing beef stock tend to produce a normal and regular amount of gain from year to year until a mature weight has been reached. Gains produced in the wintering of breeding and stocker cattle in excess of the amount required for normal growth and development,

increase the winter feed bill and tend to reduce the amount of gain possible when the cattle are turned out to summer range. The total gain for the year from extra winter feed may be slightly higher than where cattle are 'roughed' through the winter but the additional gain produced will not be sufficient to pay for the increased feed costs. The stability of the beef cattle industry in the Northern Great Plains region is therefore dependent upon the conservation and timely use of native range grass.

Breeding cows that are in good condition at the beginning of the winter season can be carried on the range or in the feed lot on low grade rations and suffer weight losses without injury to themselves or their calves. Under normal grazing conditions these weight losses will be recovered on the range during the subsequent grazing season. Work with breeding cows at the range station has therefore been planned and carried out to secure the greatest possible use from native range. Wintering results with breeding cows show that under normal weather conditions, 50 per cent of the herd can be carried on the range all winter without a supplement, provided grass is available for winter feed. Further results show that if one to two pounds of cottonseed cake per day, is fed, a herd of breeding cows can be carried on the range all winter under normal grazing conditions. A slight increase has been noted in the weaning weight of calves where cottonseed cake has been fed as a winter supplement. During years when cake is high in price considerable saving can be made in costs by feeding the cottonseed cake to thin cows only.

Calves and yearlings.—Calves require feed lot care throughout the winter season, while yearlings may be wintered on the range for a part of the time and in the feed lot during the remainder of the season. Gains produced during the winter period by stock of this class, that are over and above gains required for normal growth, are in a large measure wasted since the summer gain will be proportionately reduced. This method results in a high winter feed bill and a poor utilization of summer range, where gains are relatively cheap. Results from this station show that calves and yearlings that have been wintered on good quality alfalfa hay, or alfalfa hay and a small amount of good quality straw, produce satisfactory winter growth and are in the best condition to produce maximum gains when turned to spring range.

Approximately 75 per cent of the total land acreage in Montana is useful only for grazing purposes, and while the livestock industry represents one of the largest resources in the state, its stability is wholly dependent upon the conservation and regulated use of this vast domain. The drought of the past summer and the forced liquidation of approximately 44.2 per cent of the cattle in the drought relief counties of Montana, North Dakota, South Dakota, and Wyoming up to November 9, is a stark reminder of the fact that the ranges have been overstocked, and range feeds reduced to a negative quantity. The number of beef cattle and heifers in Montana, according to the United States Department of Agriculture Year Book amounted to 983,000 head on January 1, 1917, and 1,543,000 on January 1, 1934. It is probable that the number on hand in 1917 more nearly represents the maximum number to be carried on Montana ranges than the number on hand at the beginning of the 1934 season.

STUDIES WITH SHEEP AT THE RANGE STATION

Comparative tests on feeding either cottonseed cake or corn as a supplement for wintering ewes on the range, revealed in three years of experimental work that there is little difference in the body weights of the ewes or of the lambs when dropped and weaned, or in wool production, when each is fed at the rate of one-quarter pound per head daily. Each feeding period extended from November 1 to March 1 of the following year. During this time the individual initial, intermediate, and final body weights revealed that ewes fed cottonseed cake gained 1.3 pounds per head and ewes fed corn lost 1.2 pounds per head during the three year period. Aside from the well-accepted fact, that there is less loss from feeding cottonseed cake on the ground, the initial cost of the feed should determine the selection of either cottonseed cake or corn as a winter supplement for breeding ewes on the range.

Wintering ewe lambs.—The desirability of various methods of wintering ewe lambs has been studied for three years. The ewe lambs were all weighed individually on December 1 of each year and 100 head were placed in a feed lot and fed on alfalfa hay and grain in amounts sufficent to insure their leaving the feed lot during the latter part of March in good condition as stock sheep. All the other lambs were herded out during the winter on native grass or alfalfa pasture. The greater loss in weight at the end of the winter feeding period by the lambs wintering on the range, as compared with the

winted-fed lots, was made up as soon as grazing conditions became favorable, so that by shearing time in June there was little difference in the average weights of the two lots.

EXPERIMENTS WITH SWINE

Swine were added to the livestock work at the United States Range Station because of the opportunity afforded to study the problem of producing quality bacon from hogs raised on irrigated alfalfa pasture and the cereal grains grown in Montana. As a result of these studies some facts have been brought out, which are of special importance to eastern Montana.

A very important result is the high quality of the pork from hogs grown in this area on locally produced feeds. These hogs dress out uniformly firm carcasses. The high protein content and superior quality of the grain and forage raised here seem to produce hog carcasses of outstanding desirability. They have been marketed on the Pacific coast and at four eastern markets, and in all cases careful meat-cutting and carcass studies have been made in cooperation with the packing company killing the hogs. The opinion has always been that the hogs from the range station were of outstanding desirability.

For several years some of the carcasses were converted into Wiltshire sides and exported to the English market. One firm which handled a shipment reported that these were the best they had ever received from the United States and fully equal to the best Canadian brands. In 1931 an educational exhibit of live hogs and hog carcasses was made at the International Livestock Exposition under the caption "The Hog of the Hour," which called atttention to the quality of Montana hog products in a very effective manner. This exhibit and the exportation of Wiltshire sides has resulted in widespread publicity for the high quality of Montana pork products.

Another important fact brought out in these swine production studies is that this area in eastern Montana has some decided natural advantages with reference to pork production. The climate is healthful and invigorating so that there is very slight loss from hog flu and other respiratory ailments which are so prevalent in many of the more intensive hog-producing sections of the nation. In more than three thousand hogs marketed from the range station, there has never been a carcass condemned for disease. The fact that Montana farmers, as a rule, do not have close neighbors helps materially in preventing the spread of epidemic diseases. These favorable environ-

mental conditions enable Montana farmers who use proper production methods to market a very high percentage of the number of pigs dropped.

TURKEY INVESTIGATIONS

Turkey raising is now a million-dollar industry in Montana, and in 1929 the state ranked eleventh in the number of turkeys raised. The industry is generally a side line in connection with farming or ranching, but there are now many who produce turkeys on a large scale and several localities where the birds are raised commercially under favorable conditions of feeding and management.

The turkey must be marketed as a finished product, fat and free from pinfeathers. There is no market for feeder turkeys. Growth is largely dependent upon the birds receiving adequate amounts of protein and minerals along with the grain, green feed, and the insects generally available to the average flock of farm turkeys. These experiments have shown that the best method of furnishing the necessary suppements is to provide a dry mash containing sufficient protein and mineral constituents. Experiments with various combinations of feedstuffs have developed the formulas best suited to Montana conditions. For starting the baby turkeys (up to the age of 8 weeks) the mash should contain between 22 and 30 per cent of crude protein and for growing them out (after the eighth week) 17 to 20 per cent. Home-grown feeds can be used to a considerable extent in the mashes and up to 100 per cent in the scratch feeds, which are fed along with the mashes. Mineral supplements are unnecessary and sometimes detrimental when sufficient protein to promote normal growth is provided in the form of meat scraps, milk, or fishmeal, or a mixture of two or three of these ingredients.

Turkeys have very high vitamin requirements, especially during the first few weeks of their lives. Two per cent of standard high grade cod-liver oil has been found to be necessary to insure against vitamin D deficiency in starting feeds. This cod-liver oil also insures against vitamin A deficiency, provided it is mixed fresh before being used. Vitamin G deficiency is guarded against by including 5 per cent of alfalfa leaf meal and 10 per cent or more of dried milk in the starting mash. Growing turkeys, older than 8 weeks, can satisfy their vitamin requirements fully if they have access to a green range, which also reduces feed costs and induces normal behavior. When drought or other factors prevent the turkeys from consuming large amounts

of fresh green feed, it is necessary to include 5 per cent of alfalfa leaf meal and 10 per cent of dried milk in the growing mash.

The feed requirements of breeding turkeys are not essentially different from those of growing turkeys. Rations that permit good egg production, fertility, and hatchability have been developed. On the basis of total dry feed intake, such a ration should contain about 16 per cent of crude protein, meat scrap, dried milk, and fish meal. Vitamin requirements are satisfied by the inclusion of 4 per cent of alfalfa leaf meal and 1 per cent of standard high grade cod-liver oil. The dried milk also contributes to the supply of vitamins. Material for egg-shell making is provided by using 3½ per cent of ground oyster shell in the ration in addition to the mineral contained in other ingredients.

METEOROLOGICAL OBSERVATIONS

The passing years give us an everchanging meteorological picture, and a very interesting one. Weather has many different aspects as is evident from the observations recorded daily by the meteorologist. At the Montana Station, these include maximum and minimum temperatures, wet and dry bulb temperatures, precipitation, time and duration of rains and snow, evaporation, wind velocity, wind direction and hours of sunshine.

The climatological data for 1934 was quite unusual from the standpoint of temperature and precipitation. Only three times during the year did the temperature drop below zero—on February 25 and 26 when the minimum thermometer registered —4 and —9 degrees, respectively, and on December 25 when the temperature dropped to —3 degrees. This record is something very unusual for Bozeman and only in 1925 were there higher minimums. In that year the temperature dropped to —2 degrees on the 26th of January and again to —2 degrees on the 13th of March. From March 13, 1925, to December 12, 1926—a period of 21 months—the temperature did not drop below zero and only twice during that time did it reach the zero mark. But, notwithstanding this fact, it still remains that the average temperature for the winter months of 1934 is the warmest recorded for these months in over 50 years at Bozeman. Not only was the winter the warmest of which we have a record, but the growing months, April to October, inclusive, were also the warmest. The yearly mean for 1934 was 47.4 degrees. The nearest approach to this was in 1933 with a yearly mean of 43.8 degrees.

Aside from being the warmest year, 1934 was also the driest year, the annual precipitation being 10.54 inches. The nearest approach to this was in 1919 when the annual precipitation was 11.47 inches. In comparing the precipitation available for crop production we found that from September, 1918, to July, 1919, inclusive, there were 11.32 inches, while from September, 1933, to July, 1934, inclusive, there were only 10.89 inches. For the months April to October, 1934, inclusive, there were 6.42 inches of precipitation. In 1919 for the same months the precipitation was 7.23 inches.

The evaporation for the months of April to October, 1934, inclusive, was 49.31 inches—the greatest amount of which we have a record. In 1919 the evaporation for the same months was 44.6 inches. The nearest approach to this year's evaporation was 46.68 inches in 1929.

The average relative humidity for the months of April to October, 1934, inclusive, was 46.9 per cent. This is the lowest humidity for the same months that we have recorded at this station.

The wind velocity was above normal for April, September, and October, and below normal for May to August, inclusive. The normal average daily wind velocity is 74.7 miles. In 1934 the average daily wind velocity was 75.2 miles.

Man, from time immemorial, has been interested in certain climatological changes with the result that people have formulated many peculiar notions relative to the controlling factors of winds, rains and temperature. The changes of the moon and its relation to the earth are regarded by many as having a direct bearing on meteorological conditions.

The last few hot and dry years have renewed this same old interest and there are many speculative theories advanced to explain these abnormal weather conditions. The changes in oceanic current are held responsible by some for the high temperatures and mild winters; others believe that climate is changing and that the tendency is toward hotter and drier years. The Cascade and Rocky Mountains are thought to influence the amount of moisture carried by westerly winds during the summer months to points east of the main range of the Rockies. This seems reasonable and meteorological data show that moisture is lost from the air in passing over these ranges. The greatest loss occurs, however, during the winter months when the temperature is much warmer on the coast than inland, and when vast

equator remain upper currents until, through loss of temperature and moisture, they become heavier than the upper currents blowing from the north when they become ground winds and continue their quantities of snow are deposited in the high points in both ranges. It is reasonable to assume that during the summer months these same westerly winds will pick up additional moisture when passing over these snow-covered mountains and that this moisture may be deposited east of the main range of the Rockies. It must be remembered, morever, that these westerly winds as they come inland become warmer, which increases their water-holding capacity. This increased moisture supply makes precipitation possible, but before this can happen the temperature of these westerly winds must be reduced to the saturation point. This is accomplished by contacting some colder stratum of air, and unless such is contacted the westerly winds may pass over Montana without depositing any moisture in the form of rain. This is what happens during dry years. Why some years are drier than others it is hard to explain with our present limited knowledge of air current. It is reasonable to assume that winters of heavy snowfall in the mountains are followed by wet summers. This is not always the case. The light snowfall for the winter of 1918-19 was followed by a very hot, dry summer, but again the heavy rain and snowfall for the winter of 1933-34 was followed by the hottest, direst summer experienced in this section. While the amount of snow deposited in the main ranges of the Cascades and Rockies is a factor, it seems that other factors are also involved. It is known that trade winds blow from about 30 degrees latitude toward the equator as ground currents. It is also known that upper currents blow toward the north and south from the equator; there are also winds blowing from the north and south poles toward the equator; thus there is a general circulation of air from the poles to the equator and from the equator to the poles. Winds north and south of the parallels of 30 degrees latitude to the regions of the polar winds, are known as variables. The region between 30 degrees latitude and the polar winds is supposed to be where the upper currents from the equator become ground winds and also where the polar winds become ground winds. A difference in the temperature and moisture is responsible for these two opposing winds and shifting positions, i.e., the upper winds becoming ground winds. The upper winds blowing from the northerly direction. The upper winds from the poles remain thus

until they become heavier than the ground winds.

It is believed that the amount of heat given off by the sun is not constant, but varies from year to year. Such being the case, it is highly probable that there will be a wide difference in latitude at which these northern and southern winds meet. They may meet over Montana where they may encounter westerly winds from the coast and thus produce rain, or they may meet farther south or north and leave Montana out of the picture. Again, just what part the winds from the west play is problematic. We know that they do not extend farther east than Montana, and the similarity of Montana's and North Dakota's precipitation may lessen the value placed on the importance of western winds.

The whole theme is a speculation and advanced only to show some of the complications encountered in explaining the cause of wet and dry years. We know from a study of tree growth that these wet and dry years have occurred through the ages, but why, is yet to be explained.

METEOROLOGICAL SUMMARY FOR 1924
BOZEMAN

Highest temperature	96°, August 3
Lowest temperature	—9°, February 26
Greatest range for year	115°
Highest monthly mean	67.8°, July
Lowest monthly mean	24.9°, December
Highest daily mean	82.0°, August 3
Lowest daily mean	0.5°, February 25
Mean temperature for year	47.4°
Greatest total precipitation for 1 month	2.35 inches, June
Least total precipitation for 1 month	0.07 inch, August
Total rainfall	10.54 inches
First killing frost	September 20
Last killing frost	May 13
Number of clear days in year	95
Number of partly cloudy days in year	236
Number of cloudy days in year	34
Days with 0.01 inch or more precipitation	95
Total evaporation from April to October, incl.	49.307 inches

PUBLICATIONS

The publications of the Experiment Station for the past year included twelve bulletins, three circulars, and nine technical papers. The bulletins and circulars were printed in editions ranging from 2,000 to 5,000 copies, and with the annual report make a volume of 661 pages.

The bulletins are designed to report the results of the investigations carried on by the station staff. Many of the more technical reports are published in scientific journals.

Since the last annual report the following publications have been issued.

BULLETINS

No. 285. Experimental Studies of Foot-Rot in Sheep. Hadleigh Marsh and E. A. Tunnicliff. 3,000 copies, 29 pages.

No. 286. Montana Farm Taxes. Roland R. Renne and Bushrod W. Allin. 5,000 copies, 55 pages.

No. 287. Types of Farming in Southeastern Montana. Virgil D. Gilman. 2,000 copies, 61 pages.

No. 288. The Mosquitoes of Montana. G. Allen Mail. 3,000 copies, 72 pages.

No. 290. An Analysis of Agriculture on the Milk River Irrigation Project. P. L. Sagsvold and G. H. Bingham. 2,000 copies, 80 pages.

No. 289. Diesel Power and Field Operating Costs. Depts. of Agr. Economics and Agr. Engineering. 2,000 copies, 16 pages.

No. 291. Soils of Pondera County. L. F. Gieseker. 2,000 copies, 62 pages, maps.

No. 292. The Premature Seeding of Celery: A second Report. C. C. Starring. 2,000 copies, 14 pages.

No. 293. Feeding Dairy Cows with and Without Grain. W. F. Dickson and D. V. Kopland. 5,000 copies, 23 pages.

No. 294. Montana Insect Pests for 1933 and 1934: The Twenty-Fifth Report of the State Entomologist of Montana. A. L. Strand, 3,000 copies, 40 pages.

No. 295. Economic Changes in Montana's Wheat Area. E. A. Starch. 2,000 copies, 70 pages.

No. 296. Report on Phosphate Investigations During 1934. Jesse Green and F. M. Harrington. 3,000 copies, 30 pages.

CIRCULARS

No. 143. Mosquito Control in Montana. G. Allen Mail. 4,000 copies, 13 pages.

No. 144. Blackleg in Cattle. Howard Welch. 5,000 copies, 7 pages.

No. 145. The Prevention of Goiter in Farm Animals. Howard Welch. 3,000 copies, 6 pages.

ANNUAL REPORT

Reshaping Montana's Agriculture: The Forty-First Annual Report of the Montana Agricultural Experiment Station. F. B. Linfield. 3,000 copies, 83 pages.

TECHNICAL PAPERS

Electrokinetic properties of proteins. W. McK. Martin. Jour. of Physical Chemistry, Feb., 1934. Jour. Ser. No. 29.)

Growing fungi and bacteria in petroleum oils to predict the effects of the oils on apple leaves. Paul A. Young. Phytopathology, March, 1934. (Jour. Ser. No. 33.)

Freezing phenomena in cresoap emulsions of petroleum oils. Paul A. Young. Plant Physiology, Sept., 1934. (Jour. Ser. No. 36.)

Stem canker of hollyhock caused by **Sclerotinia sclerotiorum**. Paul A. Young. Phytopathology, May, 1934. (Jour. Ser. No. 37.)

Wheat bunt, a new food for grasshoppers. Paul A. Young. Jour of Economic Entomology, April, 1934. (Jour. Ser. No. 39.)

A method of forecasting seasonal rainfall. O. W. Monson. Monthly Weather Review, Sept., 1934. (Jour. Ser. No. 40.)

Penetration, distribution, and effect of petroleum oils in apple. Paul A. Young. Jour. Agricultural Research, Sept. 15, 1934. (Jour. Ser. No. 42.)

Temperature control in the baking test with revolving shelves in the proofing cabinet. W. O. Whitcomb. Cereal Chemistry, July, 1934. (Jour. Ser. No. 44.)

A study of the increase in weight of body and of fleece due to wintering ewe lambs on a high or a low plane of nutrition. W. F. Dickson and Frank Barnum. National Wool Grower, Nov., 1934. (Jour. Ser. No. 46.)

BUILDINGS AND IMPROVEMENTS

The facilities for the care of the experimental field crops were totally inadequate and so a small building for the use of the Agronomy Department was erected at a cost of about $2,000. It is a one-story building, 24 by 60 feet in floor area.

With C. W. A. and F. E. R. A. labor it was possible to gravel the roads on the station farm and also to gravel and fence the station steer-feeding yards.

At the Northern Montana Branch Station the same kind of labor enabled us to make very substantial progress in cleaning up the grounds where the old fort buildings were located. We had waited for nearly twenty years to find the means to do this work. It is not yet completed but much progress has been made. This same labor, using much of the old lumber from wrecked buildings, together with some new material purchased by the station, made possible the erection of a steer-feeding shed some 288 feet long and 24 feed wide, with 8 pens 36 feet wide. The yards for this feeding shed have been fenced with poles. Through the years as funds could be diverted to the task a series of apartment houses has been made out of buildings previously used as officers' quarters. These apartments have all been made habitable through the help provided by the C. W. A., together with certain materials. All these improvements have been badly needed.

THE STATION STAFF

Resignations during the year reduced somewhat the Experiment Station staff. William DeYoung, assistant agronomist in soil survey studies, resigned early in the year. William McK. Martin, associate chemist, accepted a position in the commercial field. He was succeeded by Frank T. Donaldson. C. C. Starring, associate horticulturist, accepted a position with the Federal Government, as did John Dexter of the Agricultural Publicity Department and H. E. Tower, in charge of forage crops at the Judith Basin Branch Station. During the year the work in irrigation engineering was made a separate department with O. W. Monson in charge.

FINANCIAL SUMMARY

EXPENDITURES OF THE MONTANA AGRICULTURAL EXPERIMENT STATION FOR THE YEAR ENDING JUNE 30, 1934

	Hatch fund	Adams fund	Purnell fund	State appropriations and miscellaneous*
By salaries	$8,778.29	$9,464.72	$31,374.38	$46,601.00
Labor	2,091.09	2,952.69	17,037.40	14,820.10
Supplies and materials	1,751.36	1,077.42	3,936.88	13,487.69
Communication service	57.82	1.85	52.03	1,401.30
Travel expense	911.89	901.98	3,008.23	1,947.26
Transportation of things	45.19	6.37	248.42	175.81
Publications	282.07	—	1,284.89	473.90
Heat, light, water and power	19.00	—	181.41	3,575.08
Contingent expense	—	—	2.55	15.26
Equipment	1,063.29	594.97	2,676.81	1,785.20
Buildings and land	—	—	197.00	4,248.52
Unexpended balance	—	—	—	10,083.89
Total	$15,000.00	$15,000.00	$60,000.00	$98,615.01

*This fund includes the following:

State appropriations for Home Station	$39,256.33
For Grain Laboratory and Branch Stations	29,014.28
Income from sales	30,344.40
Total	$98,615.01

BOZEMAN CHRONICLE PRINT